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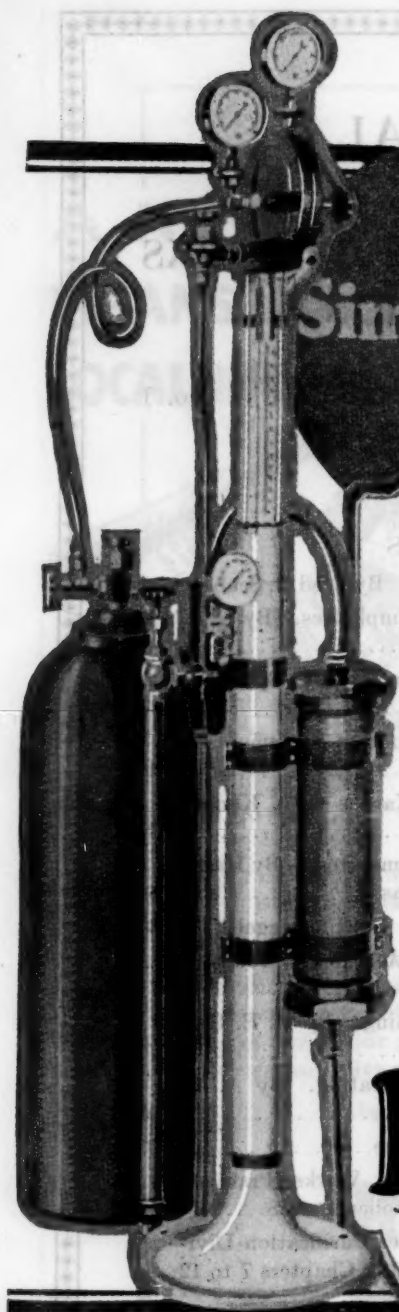
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COEFFICIENTS OF FLOW IN CONCRETE PIPE¹

By FRED C. SCOBY²

To the speaker it is a significant thing that he should be asked to contribute a paper on the coefficients for concrete pipe—not *clean pipe* or *new pipe* or *old pipe*, but "*concrete pipe*."

Here is a definite note of understanding that surfaces in contact with a flowing water prism, made of cement mortar or some form of the many products known as "concrete," have certain characteristics of flow that give definite coefficients as distinguished from those holding for other pipe materials.

In trade catalogs we still find tables for "flow of water in pipes." It was quite a shock to many of us to learn that one new pipe may carry from 20 to 40 per cent more water than another new pipe of the same size and under the same physical conditions. It has been stated that the ellipsoid of revolution, for a traverse of velocities across a pipe, generally shows that the velocity at the shell of the pipe is about half that at the center. The reverse of this appears to be the important thing, that is, the velocity at the center is about twice that at the shell and the latter is largely governed by the surface of contact between the water and the shell. In other words, if the velocities at the shell are made a maximum by favorable conditions, then this influence extends clear across the water prism to the

¹ Presented before the San Francisco Convention, June 14, 1928. CEP

² Senior Irrigation Engineer, Division of Agricultural Engineering, United States Department of Agriculture, Berkeley, Calif.

center and the average velocity throughout the prism is appreciably higher than is the case with a rougher surface of contact.

This surface influences the capacity of a line in three ways. First, if roughened by projections, the flow is reduced by mechanical throttling of the area of the pipe. As a rule this is the only influence the layman understands. Second, by rubbing friction, merely dragging back the shell velocities. Third,—and least understood—by undulations of surface, causing the filaments of flow to plunge unduly throughout the prism.

These undulations are probably of little moment in a rough pipe but, as local surfaces are improved to approach that of plate glass, the trueness of longitudinal elements undoubtedly enters into the development of the maximum capacity.

Concrete pipe, not being subject to coating blisters or tubercles, is reasonably free from the first cause of lack of capacity. However, more than any other material when new, concrete surfaces may be developed in all degrees of roughness and surface undulations. Thus comparisons between capacities of concrete pipes and pipes of other materials do not become significant until a definite process of manufacture is considered, in terms of a definite surface associated with that particular method of manufacture.

Being made of a synthetic product that can be assembled by anyone from simple elements that can be purchased in any locality, a conduit can be "concrete pipe" and still have greater individuality than pipes of any other material. Being cast in molds in a plastic state, it can be made of any shaped section. Thus the "pipe" may be round, egg or horse-shoe shaped, square or any other form that may suit the conditions of construction. As a mortar coat, it can be placed inside brick, masonry, steel or cast iron. With so much range of construction it is easily seen that concrete pipe can be made in all grades of excellence. This covers not only the strength and life of the pipe but, to an unbelievable extent, it influences the carrying capacity.

With an understanding of these conditions, it is readily seen that the capacity of concrete pipes can cover a very wide range. As one example, the best of concrete pipe as made to-day will carry more than 50 per cent in excess of that conveyed by some of the old pipe lines as laid in Southern California nearly fifty years ago. The difference lies in the interior surface of the two pipes, as originally made, not as a result of any deterioration.

HISTORICAL

The modern concrete pipe, as a conveyor of water, is a development of the last half century. Herschel³ tells us that the old Roman aqueducts were lined with concrete.

The members of this Association from the Eastern States are familiar with the cement-lined metal pipes—developed after the Civil War—so well described by the late Leonard Metcalf.⁴

The first tests of capacity on a large cement-lined conduit of which the writer is informed, were made on the new Sudbury Aqueduct in 1880. About the same time development in the citrus groves of Southern California started a use of the so-called "cement pipe," in reality a concrete pipe using small aggregate. These pipes, up to 4 feet in diameter, were also employed in the conveyance of water to the towns in this section. By 1890 several thousand miles had been installed. To-day there are few towns of 1,000 people, located in California, where there is not one or more concrete pipe yards.

Another branch in the development of the concrete pipe came with the construction of the United States reclamation projects in the Western States. This work began about 1904. Here was the first extensive use of reinforced concrete for the construction of jointed and monolithic pipes up to 60 inches or more in diameter. These pipes were placed under pressure heads up to more than 100 feet whereas the old California pipe, without reinforcement, was always regarded as a pipe to be subjected to 20 feet of head or less. For many of the pipe lines on these Federal projects concrete was used for portions of the lines under about 60 feet of pressure head and wood-stave or steel pipe used for the higher-head sections. A similar policy was later adopted by the Los Angeles Aqueduct for their siphons 10 feet in diameter or larger.

During the past ten or fifteen years great improvement has been made in all types of concrete pipe. Along the Pacific Coast nearly all of the smaller jointed pipes, largely used for irrigation, are now made by machines with packer heads and mechanical trowels. For sewer work, railroad culverts and the like, larger semi-wet pipe is packed in the molds with mechanical or hand tamping rods. For municipal use reinforced concrete pipe in long units is poured as a

³ Frontinus and the Water Supply of the City of Rome, by Clemens Herschel, Longmans, Green and Co., New York, 1913.

⁴ Eng. News, Vol. 61, p. 2, January 7, 1909.

wet mixture into rigid forms or is spun centrifugally. For high-head work a steel cylinder, to act as a water-tight membrane only, is placed between the inner surface of concrete and the steel cage that constitutes the reinforcing. A modification of the cement-lined iron pipes mentioned above gives cement inner surfaces within cast iron or steel pipe. Even pipes of house service sizes are being lined with a cement coat of appreciable thickness. Many power and municipal supply water tunnels are now being lined with concrete placed

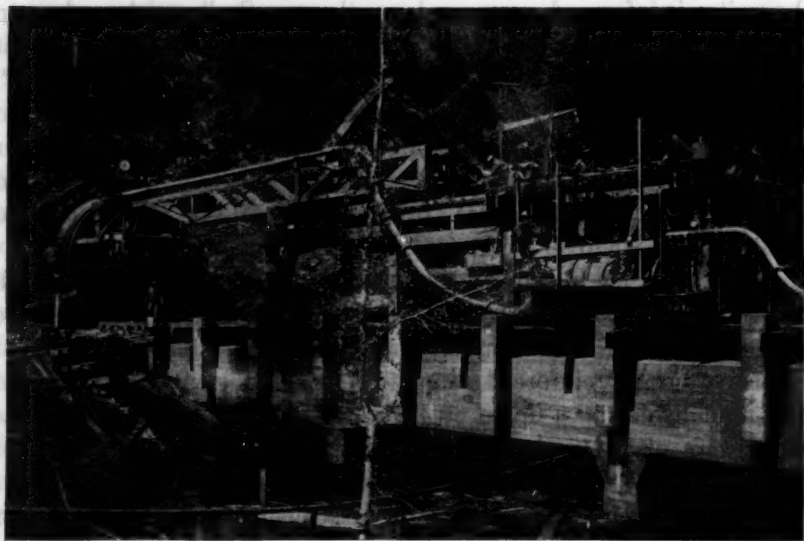


FIG. 1. CONCRETE GUN AT PIT RIVER NO. 3 TUNNEL, CALIFORNIA

Mixture dumped in tank at right; lid clamped, then compressed air forces concrete through 6 to 8-inch tube extending behind forms, where a division-box effects equal placing over the haunches.

pneumatically behind smooth oiled steel forms, using a concrete gun as shown in figure 1. With a cement gun, very dense linings are shot against old surfaces of various kinds, as well as in new locations. Special concretes with admixtures of asbestos or waterproofing compounds show very smooth interiors. Likewise, concrete pipe is being made with inner surfaces of other materials so that the conduit has lost its identity as a concrete pipe, in capacity classification.

As the practice of the American Water Works Association deals largely with the conveyance of water for municipal use, the types of

pipe that are used for this purpose will be accented, in the following discussion of capacity and coefficients. However, the other kinds of concrete surfaces will also be touched upon, for sometimes the operator of the waterworks of a small municipality must also consider the conveyance of storm-water or sewage that may not require the best grade of pipe.

CAPACITY FORMULAS

In the following discussion coefficients will be mentioned for but three formulas, as follows:

1. The Scobey formula:⁵

$$V = C_s H^{0.5} d^{0.675} \quad (1)$$

Here V is the mean velocity, in feet per second; H is the loss of head in feet per 1,000 feet of pipe, and d is the inside diameter in inches.

This formula can be written in the exponential form quite common in hydraulic literature of the past two decades:

$$H = k \frac{V^2}{d^{1.35}} \quad (2)$$

Here we return to the long-held idea that the loss of head is proportional to the square of the velocity. When all available observations are plotted on logarithmic paper the slope lines can hardly be construed in any other general terms than at a value of 2.00.

2. The Williams-Hazen formula⁶

$$V = C_w R^{0.63} s^{0.54} 0.001^{-0.04} \quad (3)$$

⁵ This formula was derived by the speaker in his position as Senior Irrigation Engineer of the Division of Agricultural Engineering, U. S. Department of Agriculture. The formula resulted from a study made in 1915-1916 of 184 observations for loss of head on pipes flowing under pressure and 85 observations on concrete-surfaced pipes, tunnels or other covered conduits but with the water surface exposed to the air; that is, flowing as an open channel. Of all the above observations the majority were made by a field party under his direction. The present paper may be taken as a summary of the findings in that study as supplemented by additional data developed since 1917. The observed values, discussion and deductions are all found in "The Flow of Water in Concrete Pipes" by Fred C. Scobey, Bul. 852, U. S. Dept. Agriculture, Washington, D. C., Pub. 1920 and reprinted 1924. This publication is obtainable on request to the Department at Washington, D. C.

⁶ The Williams-Hazen formula was derived from consideration of some 1100 observations on all kinds of pipes, of which only about 20 were on small cement pipes. See No. 61 in table 1.

See Hydraulic Tables, Williams and Hazen, 3rd edition, 1920, John Wiley and Sons, New York.

TABLE 1
Summary of experimental data on the flow of water in concrete pipe of grades A, B, and C

REFERENCE NUMBER	NUMBER BULLETIN 852	NAME AND LOCATION OF PIPE	INSIDE DIAMETER inches	AGE AT TIME OF TESTS years	LENGTH OF REACH feet	RANGE OF VELOCITIES feet per section	YEAR OF TESTS	LENGTH OF UNITS feet	NUMBER OF TESTS	COEFFICIENTS			AUTHORITY	REMARKS
										Scobey C_s	Williams-Hazen C_w	Kutter n		
1	29	Grade A. Jointed, poured pipe Deer Flat Forest, Idaho, U. S. B. R.	36.0	3-5	7,282	5.45-9.06	1915-7	6	6	0.404	136.1	0.0109	Scobey	Pipe straight. Cast in steel forms, very wet mixture Supply line beyond filter plant.
2	*	Birmingham, Alabama	36.0	New	6,320	3.59-3.70	1928	12	2	0.397	141.5	0.0106	Berry	Pipe steam-cured in forms Lake Prince line. Pipe steam-cured in forms
3	*	Norfolk, Va., supply line	36.0	3	11,458	2.89	1925	12	1	0.380	138.0	0.0112	Maury and Taylor	Classed as best grade 10 years ago.
4	*	Same pipe, another reach	36.0	3	13,043	2.90	1925	12	1	0.392	142.0	0.0109	Scobey	Short units compared present lengths
5	30	Victoria Aqueduct. B. C. Inv. siphon	42.0	1	1,336	1.01-2.91	1916	4	9	0.375	141.8	0.0112		
6	31	Same line; a shorter siphon	42.0	1	378	1.92-2.59	1916	4	4	0.303	146.8	0.0108	Scobey	Same as above. Nos. 5 and 6 on continuous curvature. Steam cured
7	33	R. Siphon, Umatilla project, U. S. B. R.	46.0	New	9,831	3.98-4.21	1912	8	4	0.300	138.3	0.0112	Newell	Straight in plan view. Under 110 foot head. Coated with neat cement
8	32	Same siphon, 4 years later	46.0	5	9,774	1.41-3.17	1915	8	3	0.402	151.5	0.0105	Scobey	No. 7 tests required adjustments. No. 8 included friction loss only
9	*	Conduit No. 10 Denver supply, Colo.	54.0	4	18,598	2.58-3.50	1925	12	2	0.409	151.0	0.0106	Scobey	Pipe quite straight. Inside very smooth and slick from thin slime. See No. 3

10	•	Same conduit; new portion	54.0	New	19,676	2.58-3.50	1925	12	2	0.382	140.5	0.0112	Scobey	Simultaneous with No. 9 above. Pipe sinuous vertically. See No. 3
11	•	Two reaches above combined	54.0	2 av.	38,274	2.53-3.50	1925	12	2	0.305	146.0	0.0110	Scobey	From gage at upper end No. 9 to gage lower end No. 10 above. See No. 3
12	•	Spavinaw Aqueduct, Tulsa, Okla.	54.0	New	21,047	2.63	1924	12	1	0.409	152.1	0.0106	Scobey	Units steam cured. Line quite straight, near lower end of conduit
13	•	Same	60.0	New	80,898	2.25	1924	12	1	0.402	152.4	0.0107	Scobey	Long reach; only 52 degrees of bends in total. Near upper third of conduit
14	•	Same	60.0	New	34,788	2.25	1924	12	1	0.386	145.4	0.0111	Scobey	At upper end of conduit; includes 456 degrees of bends, not curves
30	•	<i>Grade A (continued).</i> Jointed, centrifugally cast pipe. (Tentative; —need more data.)	42.0	New	24,060	1.60-2.82	1927	8	5	0.403	150.0	0.0105	Scobey	Contains 700 degrees curvature, radii from 100 to 1,000 feet
31	•	Riverside, Calif., trunk line Same line, following No. 30 above	42.0	New	6,226	1.60-2.82	1927	8	5	0.402	149.8	0.0106	Scobey	"Straight" in plan, 25 degrees in 4 gentle curves
40	35	<i>Grade A (continued).</i> Monolithic; steel forms oiled Simms Cr. siphon, U. S. B. R., Montana	63.5	7	1,138	3.02-6.39	1915		6	0.407	147.0	0.0108	Scobey	On gentle sag curve. Interior coated neat cement. Very smooth
41	37	Average of 8 siphons, Catskill Aqueduct	110.0		various	various	1915			0.405	142.7	0.0109	Moore	Steel pipes lined with 2-inch grout placed on metal covered wood form
42	41	Ontario Power Conduit No. 2, Canada	216.0	4	6,466	4.0-20.0	1913-4			0.427	152.8	0.0102	Johnston	Inside hand polished with carborundum bricks. Exceedingly smooth

TABLE 1—Concluded

REFERENCE NUMBER	NUMBER BULLETIN 852	NAME AND LOCATION OF PIPE	INSIDE DIAMETER	AGE AT TIME OF TESTS	LENGTH OF REACH	RANGE OF VELOCITIES	YEAR OF TESTS	LENGTH OF UNITS	NUMBER OF TESTS	COEFFICIENTS			AUTHORITY	REMARKS
			inches	years	feet	feet per section		feet		Scobey C_s	Williams-Hazen C_w	Kutter n		
		Grade A (continued). Thin linings in metal pipe. Placed tentatively in this grade												
50	•	Charleston, S. C., lined cast iron	5.62	New	500	1.20-4.45	1922		6	0.407	137.3		Gibson	Believe these first tests on cement-lined cast iron. See 51, 52, 53
51	•	Same (very short reach)	5.87	New	250	2.46-5.61	1924		5	0.437	144.6		Gibson	Discount somewhat. Compare with Nos. 50, 52 and 53
52	•	Same, short reach for diameter	15.5	New	500	0.89-2.01	1922		3	0.362	137.5		Gibson	Believe longer reaches would have yielded more consistent results
53	•	Same, short reach for diameter	15.5	New	500	0.89-2.44	1923		7	0.353	128.6		Gibson	Pipes 50-51 lined with $\frac{1}{4}$ -inch cement. Nos. 52-3 with $\frac{1}{2}$ -inch
54	•	England, mortar-lined steel	30-36	New	57,010	3.34-4.40	1928	18	1	0.410	145.0	0.0105 =	Gourley	Mortar-lined centrifugally. Coating of 'slick' manganese alime
60	18	Grade B. Jointed, poured pipe												
		Temescal Water Co., Calif.	19.9	4	2,163	0.99-2.54	1916	3	5	0.344	125.0	0.0117	Scobey	Reinforced, short lengths, inside coated neat cement
61	19	"Wrought-iron, cement lined"	20.0			0.95-4.04	1880		12	0.345	121.3	0.0117	Fanning	No description given by Fanning
62	24	D ₁ siphon, Umatilla project, U. S. B. R.	30.0	New	1 mile	3.39-3.61	1911	4	3	0.405	144.0	0.0106	Newell	Coefficients satisfy grade A. Description, grade B

63	24a	Same pipe, 4 years later	30.0	4	5, 026	1.04-2.45	1915	4	3	0.331	122.8	0.0124	Scobey	Low velocities in siphon between canals subject to silting. Newell regards this test highly. He notes possibility of sand inside
64	25	R ₃ siphon, same project, Oregon	30.0	4	3, 658	2.73	1912	4	1	0.351	126.0	0.0119	Newell	Short lengths, in oiled forms until set. Approaches grade A
65	26	Prosser pressure pipe, U. S. B. R.	30.5	4	2, 276	4.88-5.78	1916	4	7	0.362	123.3	0.0117	Scobey	Tunnel, lined with 17 inches of concrete spaded against oiled steel
70	39	Grade B, Monolithic, Rondout Tunnel, Catskill Aqueduct	174.0	New	8, 419	1.53-4.67	1915		8	0.355	136.8	0.0124	Moore	Same remarks; also. Description and some of tests show almost grade A
71	40	Wallkill Tunnel, Catskill Aqueduct	174.0	New	13, 941	1.53-4.67	1915		9	0.357	136.8	0.0124	Moore	The best pipes of this construction approach grade B. Applies to this pipe
80	*	Grade C, Jointed, forms immediately removed. Santa Maria, Calif., supply line	18	New	6½ miles			3	1	0.337	119.7	0.0119	Neel	Rough construction and 1 test indicate grade C. Average, grade B
90	20	Grades D to B, Monolithic, wood forms Clavey siphon, Oakdale District, Calif.	23.7	3	1, 046	1.55-1.95	1916		3	0.347	127.3	0.0117	Scobey	

Note: In column 2, asterisks (*) indicate data developed since publication of United States Department Agriculture Bulletin 852 on "The Flow of Water in Concrete Pipe." Full description of tests and findings in detail, will be found in this bulletin, which is obtainable on request to the Department at Washington, D. C. In column 3, U. S. B. R. refers to United States Bureau of Reclamation, formerly the United States Reclamation Service.

Here V is, as before, velocity in feet per second, R is the hydraulic radius, in feet, and s is the hydraulic slope in feet per foot of pipe.

For the comparison with the speaker's formula as in (2) above, we can write (3) as

$$H = k \frac{V^{1.852}}{d^{1.167}} \quad (4)$$

This formula is excellent in comparing pipes of all materials, but the speaker wishes to point out that there is a rather marked difference in the exponents of formulas (2) and (4). For any given velocity the value of C_w appears higher as the diameter increases. Time and additional experiments only will determine which of the two formulas above more nearly fits concrete pipe. Both will be used in this discussion.

The third formula is that of Kutter-Ganguillet—more generally known as "Kutter's," which needs no further elucidation here. Suffice it to say that it was derived from a consideration of 81 series of gagings on open channels, and hardly any present-day authority on flow of water recommends it for consideration of capacity of pressure pipes. However, it is still used for the study of flow in pipes and tunnels serving as "flow lines;" that is, with the surface exposed to the air.

We shall now sketch over the coefficients to flow for concrete surfaces not often encountered in waterworks practice and then devote more space to those of direct interest to this Association. Some of the members of the Association will probably wish some comment as to the influence of temperature of the water, through the resulting change in viscosity. Warm water flows more freely and there is such an influence, but its range changes the capacity less than 2 per cent from a mean between the coldest and the warmest waters found in ordinary practice. For most concrete surfaces, estimates of true coefficients cannot be prophesied with sufficient precision to consider this 2 per cent. Hence it will be ignored in the following discussion.

Old "California" pipe—Grade D. This pipe was made of a mixture so dry that it hardly took a set when squeezed in the hand. It was hand-tamped in molds and the steel forms immediately removed. It was seldom truly round and the inside surface was densely netted with a prickly surface which was afterward smoothed over by a brush coat of cement wash. Made in 2-foot units the assembled line had offsets or "shoulders" scattered throughout its length. Many of the

lines in the early days do not appear to have had the mortar "squeeze" at the joints smoothed down. It was finally appreciated that these "fins" of cement retarded the flow and it became customary to drag a sack of straw or in some other manner wipe the joints. For the earlier lines, made during the "80's" the coefficient in our formula was found to be about 0.27 which conforms roughly to a value of Hazen-Williams C_w of 90 for the sizes and velocities used. These lines ranged from 6 to 36 inches in diameter with occasional pipes 48 inches in size. Many of them were designed for a value of Kutter's $n = 0.013$, but 0.014 to 0.015 would have been closer. Velocities were nearly always under 5 feet per second. For the most part the water is pumped from the gravel cones so common to the citrus region. The water is clear. An examination of many of these old lines shows no change in surface whatever. They have carried water for nearly fifty years apparently without change. Many lines laid at the same time did not contain sufficient cement and quickly went to pieces.

New "California" pipe—Grade C. During the last decade the practice has entirely changed along the West coast. For the most part pipes are made with a relatively wet mixture tamped by machine into molds, usually 2 feet but sometimes 3 feet long. Greater care in coating the interior and in wiping the joints of the assembled line yields coefficients of between 0.310 and 0.345 in our formula, which conforms to Williams-Hazen C_w of 110 to 120 and Kutter's $n = 0.013$ to 0.012 for pipes larger than 12 inches in diameter. This improvement in practice has increased capacity 20 to 30 per cent. Until this construction is fully standardized and uniformity is assured, it is recommended that the more conservative coefficients of $C_s = 0.310$ or $C_w = 110$, or Kutter's $n = 0.013$ be used.

Grade B. Thus far we have not considered a pipe cast against oiled forms or allowed to remain in the molds until rigidly set.

From a capacity standpoint the essentials of these pipes consist of using a reasonably wet mixture in well oiled forms of which there are sufficient so that permanent set can be developed before the molds are required for another casting. The pipe units—either plain or reinforced with steel—in sections 2 to 4 feet long, as a rule, are then washed with a coat of neat cement. The assembled lines have a characteristic interior that results in coefficients of about 0.345 in our formula, conforming fairly closely to Williams-Hazen $C_w = 120$ or to Kutter's n from 0.012 to 0.013, increasing with size.

The lines up to about 30 inches, built by the United States Reclama-

tion Service (now the Bureau of Reclamation) were typical of the first pipes of this class. The method of manufacture of both grade C and grade B pipe have been described by Etcheverry.⁷

Monolithic pipe—Grade A. At about the same time that the Reclamation Service was making jointed pipe in long lengths of a wet mixture, its engineers were also casting circular monolithic concrete pipes against oiled metal forms and washing the resulting surface with neat cement. The coefficients for such pipes appear to be about the same as those given for Class A jointed pipes, described below.

Grade D to B. When wood forms are used, of course, there may result a wide variety of surfaces, depending on the condition of the lumber, the care of the carpentry work, the greasing or soaping of the forms and so on. For the poorest wood-form work we find coefficients in our formula of about 0.270 as for old California pipes, while the best wood-form work yields a surface corresponding to our $C_s = 0.345$, as above.

We now come to the types of concrete pipe and cement lined pipe that may be considered adequate for modern municipal supply lines. These may be divided about as follows:

Jointed pipes, Grades A to B

“Poured” pipe

Centrifugally-cast concrete pipe

Centrifugally-cast cement lining in metal pipe

Monolithic pipes, Grades A to D

Concrete lining, placed inside assembled riveted steel pipes

Concrete lining in rock tunnels

Ordinary form-work linings

Concrete “gun” work behind forms

Guniting work without forms

After discussing the features of construction that affect the carrying capacity, a table will be given that shows the average elements of experiments now available.

Jointed pipe—Grade A. The modern concrete trunk line of reinforced concrete poured pipe is made in units 12 feet long, as a rule, with 20-foot lengths for submarine or other special work. As made for the Tulsa and Denver lines, with which the speaker is familiar, the units were cast of a rich mixture deposited against heavy, rigid, oiled, vertical, steel forms. The controlling elements of the

⁷ Irrigation Practice and Engineering, by B. A. Etcheverry, McGraw Hill Co., New York, 1916, Vol. 2, page 310 et seq.

reinforcing cage are the heavy end rings of protected steel. These rings are short cylinders which fit one inside the other, with contacts based on but $\frac{1}{16}$ of an inch tolerance. After the concrete is poured and carefully spaded against the forms, the pipe is steam cured, resulting in a very smooth, hard, interior surface, with remarkable uniformity of dimensions. At Tulsa, ten random sections were measured in two diameters. The average computed area agreed with the theoretical area to the third significant figure. These sections were of 54- and 60-inch size. In the assembled pipe line the joints make contact at the steel rings with a lead gasket between, thus allowing some movement at each joint without leakage of water. The precision of manufacture in the units shows in the finished line, which can be considered, from a capacity standpoint, as virtually without joints. That is to say, a straight-edge will span across all joints and practically make contact with straight elements on both sides. The calking space allows a couple of inches within which to make a smooth transition between all adjoining elements. Likewise, the surface of the interior is free from undulations. All of this endeavor toward perfection is reflected in the resulting pipe capacity. At the time "Flow of Water in Concrete Pipe" was written, in 1917-1918, a coefficient of 0.370 in our formula was recommended for the highest grade of concrete pipe. The corresponding values of Williams-Hazen C_w are about 140 for slopes below 0.2 per 1,000 feet, and between 130 and 140 for slopes between 1.5 and 0.2 feet per 1,000 feet, and between 130 and 120 for slopes up to 10 feet per 1000 feet.

At that time it was mentioned that "A few of the pipes upon which experiments were made appear to have coefficients higher than 0.370, but the writer wishes to be conservative in recommending a coefficient that necessitates a surface so nearly ideal. That is to say, a better surface may be attained in construction than should be anticipated in design."

Reference to table 1 shows that experiments made by various hydraulicians have been made on several long reaches of various sizes of pipe that would qualify in this grade. There appears to be enough evidence at this time to state quite definitely that long lines of reasonably straight pipe of this type, when new, will have coefficients close to 0.400 in our formula or between 140 and 150 as a value of C in the Williams-Hazen formula for lines larger than about 30-inch. These pipes, operated as flow lines, that is as open channels, will have a value of n in the Kutter formula under 0.011.

A reasonable query at this time might be "What are the ultimate coefficients, say, for a pipe with a surface the equivalent of plate glass?" I believe a value of 0.420 in our formula or between 145 and 160, depending on sizes and velocities, as a value of C_w in the Williams-Hazen formula can be considered as representing the absolute ideal. It might be added that these coefficients would give a capacity only about 5 per cent more than has been found in most of the grade A lines listed in the table. We have two factors in the surface approaching the ideal. One is smoothness like the plate glass mentioned above, and the other is "slickness" caused by a deposit without body but so slippery that one can hardly stand within the conduit. This slime may possibly be gelatinous colloidal material worn from gravels by attrition, carried along in the water, and deposited on the walls of a conduit. So long as this slick deposit remains as a film only it is believed that the capacity is slightly increased. When slimes become thick and spongy and incude mossy stringers then the capacity of course is reduced.

We have now established a conception of the characteristics for the highest grade of concrete pipe, from a capacity standpoint. Reference to the table below shows that the Tulsa, Denver, Norfolk and Birmingham pipes, upon which tests have been made, all qualify as jointed, poured pipe. Likewise it is to be noted that several of the lines built by the United States Reclamation Service, in units from 4 to 8 feet long, qualify in this class. Only the most rigid adherence to specifications that demanded hydraulic efficiency, could have yielded this result.

A comparison of surfaces and tests on the Riverside, California, line show that we can place centrifugally-cast pipe in this same category, of grade A, at least in a tentative way, subject to further proof as more tests become available.

Jointed pipe, of centrifugally-cast units, is now made in two general ways, so far as developing the interior surface is concerned. The first consists of a reinforced concrete unit between steel ends of a tongue and groove type. The final joint consists of steel on steel with a self-caulking lead gasket between the rings on a longitudinal face. As in the poured pipe described above, the precision of the steel joint rings determines the smoothness of the contact between units.

The other method of casting gives cylinders with tongue and groove ends of concrete. The finished joint in the assembled line is formed

by the abutting ends of the units under reinforced concrete collars. Many of the federal Reclamation Service pipes from 30 to 48 inches in diameter were laid with such collars.

The Riverside pipe listed in table 1, was of the collar type. The inside surface at the joint cracks is not quite so perfect as in the Denver and Tulsa lines, made of poured pipe. However, these imperfections appear to be neutralized by the general surface developed in the centrifugal spinning. The type is shown in figures 2 and 3.



FIG. 2. RIVERSIDE, CALIFORNIA, 42-INCH LINE (NO. 30-31 IN TABLE 1)

Units centrifugally spun as cylinders. Collars cast separately and caulked to end of cylinder as shown.

Concrete, as made by the centrifugal process, is distinctly characteristic. As the wet mixture is thrown into the whirling mold, centrifugal force compacts it against the steel shell and brings all excess water and laitance to the inside. The inert laitance should all be removed so that the final interior surface will be of practically neat cement. The cross-section of a centrifugally-cast pipe shows a very dense marblelike concrete with a typical hard inner facing of cement.

Until more tests are available, to supplement those on the Riverside

line, we can assume a coefficient of 0.370 in the Scobey formula, or of from 130 to 140 in the Williams-Hazen formula;—increasing with the size of pipe and decreasing with the velocity—as conservative for reasonably straight lines of centrifugally-cast pipe not subject to siltation. As stated above, the Riverside line showed coefficients as good as those in the best poured pipe.

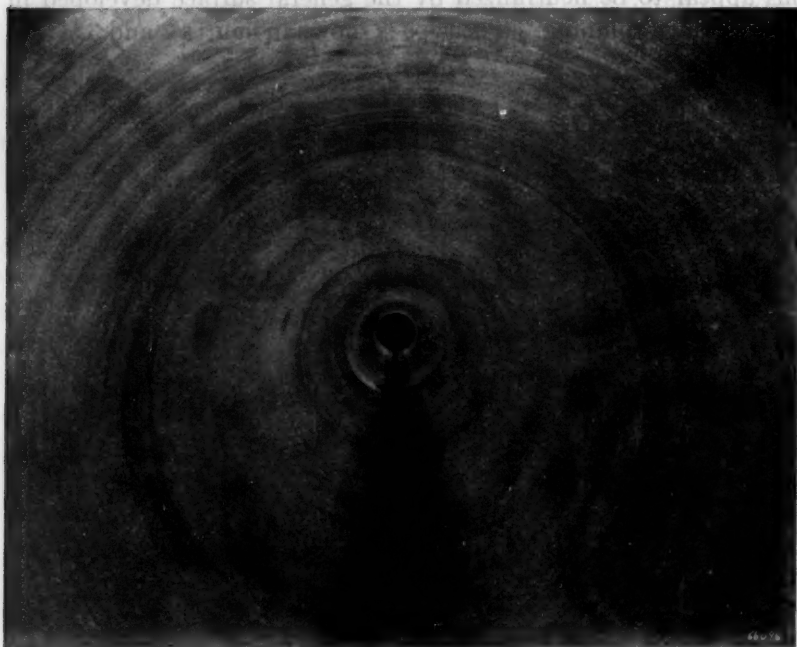


FIG. 3. RIVERSIDE, CALIFORNIA, 42-INCH REINFORCED CONCRETE LINE
(No. 30-31 IN TABLE)

Of 8-foot units centrifugally cast. The dark streak on bottom is shadow of car carrying moving light for exposure of negative.

The next pipe considered will be a cement or concrete interior for metal pipes. So far as known there have been no tests on the pipes developed during the last decade, with the exception of the ones listed below. Mr. J. E. Gibson has described the Charleston, S. C., lined cast-iron pipe, and Mr. H. J. I. Gourley, of London, in correspondence with the speaker, says of a pipe laid in England about two years ago:

We have recently tested the carrying capacity of some 2 miles of 36-inch internal diameter, mortar lined (by centrifugal process) steel pipes, and find

that the value of C in the Scobey formula works out at 0.410. The pipes were in 18 and 19 foot lengths, the nominal internal diameter was used in determining the value of C , but from measurements made from time to time during the laying of the pipes, I do not think the actual average dimensions differ materially from the nominal. No allowance was made for the additional losses of head at bends, (bevels) etc.; if these were taken into account, C , would have a slightly higher value. The main had been conveying filtered water which had been hardened artificially to a slight alkaline reaction.

From consideration of the letter above and pipes of this type I have seen, it is recommended that such mortar lined jointed pipe be classed as grade A, at least until more tests are available. The tests on the Charleston lines do not show consistent values. C , ranges from 0.353 to 0.437, with an average value slightly below 0.400, but the speaker is aware of the fact that tests on reaches of from 250 to 500 feet are likely to yield inconsistencies. Relatively long reaches are highly desirable in order to smooth over experimental errors.

Of monolithic conduits, we will consider those adequate for modern municipal supply lines when cast against heavily braced rigid oiled steel forms with the surface of the invert as good as the arch. If the resulting line is free from numerous cracks that require tar painting to prevent leakage, it is recommended that a coefficient of 0.345 in the Scobey formula or of 120 in the Williams-Hazen formula be used for new lines. That is, the line should be designed as for grade B. However, it is quite possible that coefficients for grade A may be attained. A definite surface is more difficult to prophesy for a monolithic conduit than for a pre-cast line.

All form-offsets or shoulders should be tapered off after the forms are stripped. A 10 per cent difference in capacity is cheaply attained by such improvement.

If a monolithic line is polished, like the Ontario Power conduit No. 2 (see No. 42, table 1) it will class as a grade A pipe.

If the invert is shot with a cement-gun and not smoothed over or if otherwise badly roughened, even grade B will not be attained and a capacity from 10 to 20 per cent deficient may be expected.

In lining tunnels with concrete an excellent surface is attained when heavy oiled steel forms are used and the concrete compacted back of them. This placing of the concrete is best accomplished when deposited through a 6 to 8-inch tube connected to a "concrete gun." The resulting surface is free from air pockets and compares very favorably with the best of poured or centrifugally-cast pipe (Fig. 1).



FIG. 4. TUNNEL, PIT RIVER No. 3 POWER PLANT, CALIFORNIA

Lined with reinforced concrete placed behind oiled forms with "concrete gun".

Until data are available on horseshoe shaped tunnels of this construction a coefficient of 0.345 in the Scobey formula or of 120 in the Williams-Hazen formula is recommended.

The speaker is quite certain that a true circular shape is more efficient, hydraulically, than other shapes of the same hydraulic radius. It is believed this would be particularly true in very sinuous lines.



FIG. 5 SACRAMENTO OUT-FALL SEWER.

There is a wide range of capacity in hand tamped or machine made pipe, in relatively short unit lengths. If rigid oiled forms are used and the concrete allowed to set before stripping molds then Grade A is approached. If forms are immediately removed, slight distortions result in lines varying from Grade C up to Grade B.

Flow in the circular Victoria Aqueduct, which is more on curves than on tangents, showed a remarkably smooth surface on the water, when the surface in the flow-line was viewed through the manholes.

Tunnels, or pipe linings, shot with a cement gun offer a very wide range of surface. The meagre available data on capacity of gunite surfaces in open channels show values of n in the Kutter formula of about 0.017 when the surface is left as first shot. From this initial

surface improvement can be made by brushing or troweling. The guniting process gives a surface initially both rough and undulating. Improvement of the surface will yield heavy dividends in capacity, say up to 25 per cent. The endeavor should be to preserve the excellent water-tight property of gunite, but to smooth and align the surface.

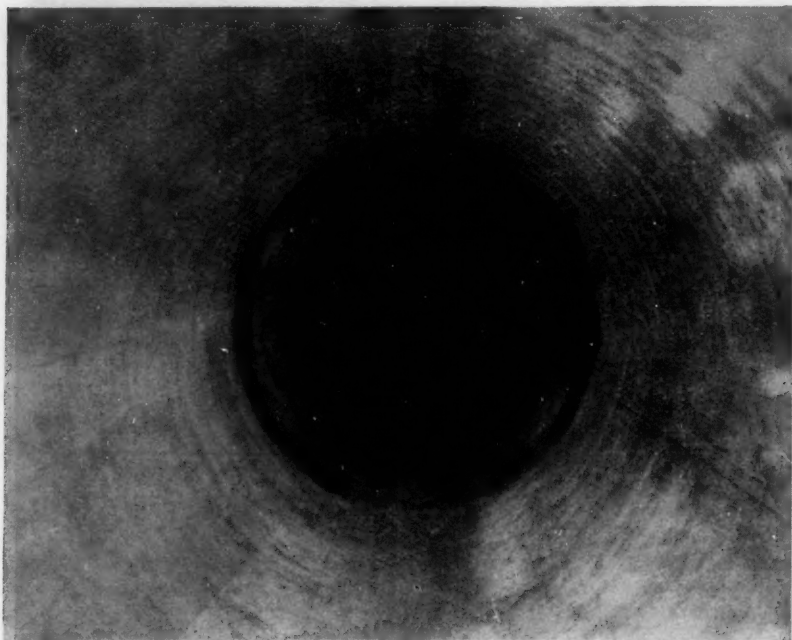


FIG. 6. PROVIDENCE, R. I. 60-INCH REINFORCED-CONCRETE PIPE CAST IN OILED STEEL FORMS IN 12-FOOT LENGTHS

The dark joint made with fine-ground neat cement. Similar to construction of Tulsa, Denver, Birmingham, Norfolk lines listed in table.

To sum up the experience now available on concrete surfaced pipes of the best grades: For grade A, the speaker's recommendation, made in 1920, of a value of C_s , in the Scobey formula of 0.370 or of Williams-Hazen C equals 140 appears conservative for large new lines, with a strong likelihood that corresponding coefficients of 0.400 and up toward 150 will be attained. In Bulletin 852 this type was called "Class 4." For small lines or high velocities values 10 points less should be chosen for Williams-Hazen formula. Monolithic work may

attain grade A, especially if hand treated after construction, but grade B should be assumed as a usual thing.

For grade B, $C_s = 0.345$ in Scobey formula or 120 in Williams-Hazen formula. Jointed pipe as now made by machine tamping in steel forms without oiling in lengths of 2 to 4 feet, slightly out of round, slightly varying in size. Also tunnel lining when placed with a concrete-gun behind oiled steel forms. Future tests may show

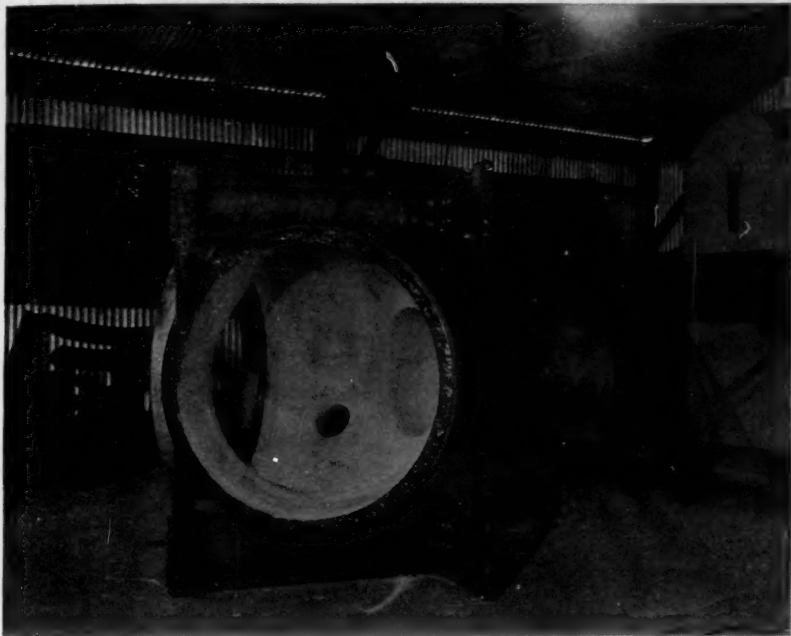


FIG. 7. A "SPECIAL" FOR STEEL-CYLINDER CONCRETE PIPE

Interior surface developed by hand troweling with cement and sand mortar. Note rounding of edges to reduce friction losses.

this method to yield grade A conduits. Also monolithic work with steel forms if a seepage coating is necessary. If uncoated the surface may approach grade A.

For grade C, $C_s = 0.310$ in the Scobey formula or $C_w = 110$ in the Williams-Hazen formula. This class covers types that are not used to any great extent for municipal supply lines. Pipes made of a wet mixture in 2 to 3-foot lengths, where the molds are immediately stripped. Also for good wood-form monolithic work.

EFFECT OF AGE ON CAPACITY

Thus far coefficients have been given for new lines. Evidence is accumulating that little or no deterioration may be expected as a rule, due to any chemical change in the concrete surface. This of course does not apply to siltation or other accumulation of debris due to the fact that the supply comes from open channels or wells that contribute more or less sand and detritus. Accumulations such

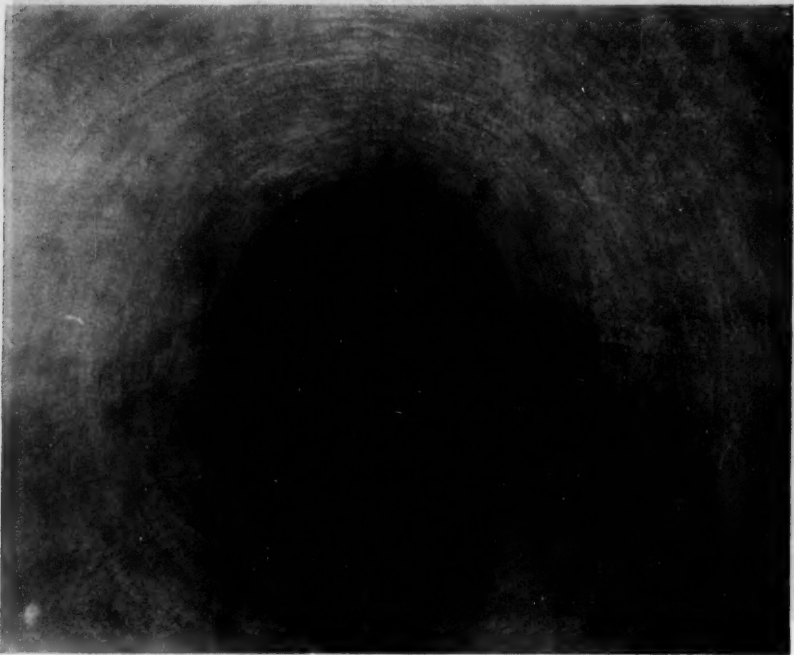


FIG. 8. A TUNNEL LINED WITH GUNITE SHOT AROUND STEEL REINFORCEMENT

Surface then well brushed to improve capacity

as these will choke any pipe and the designer must know conditions in order that a proper excess capacity be allowed. It has been observed that hard waters in the middle-western states build up a line incrustation in concrete drain tile. This fact would require consideration in municipal supply lines as well. Retarding slime deposits come rather quickly or not at all. When cleaned out, they quickly return, so it is better to allow for them, when anticipated, in excess capacity, and do not figure on cleaning the line. Factors of safety may be

applied in two ways; one is to design for a lower value of the coefficient of flow and the other is to choose the value of the coefficient as nearly as may be and to design for capacity of from 5 to 15 per cent more than the quantity desired, depending on the type of pipe and the necessity for attaining a definite capacity.

CONCLUSION

Concrete pipe ranks with the most efficient water conveyors we have. It can still be concrete pipe and be one of the least efficient

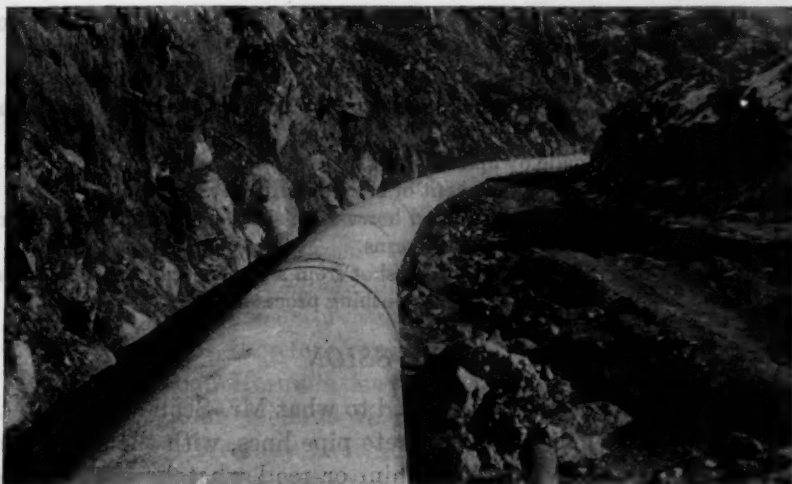


FIG. 9. FORT COLLINS, COLORADO, SUPPLY LINE CENTRIFUGALLY CAST IN 12-FOOT LENGTHS

Note absence of collars. Joints formed by metal rings, with lead gasket self-caulked on longitudinal faces between rings.

types of conduit. The standards set by the maker of the pipe, the engineering care used in alignment and grades, and the methods of construction all contribute to the carrying capacity of the finished line.

As the object of a conduit is to convey water from one location to another, then capacity should enter into the economics of the line, along with life, first cost, and maintenance costs. All these items should be considered in equating one material of construction and one type of pipe against another. Furthermore, "concrete" alone cannot be compared with other materials of construction, but

the specific type of concrete conduit should be compared with the other materials and with the other types of concrete pipe.

As to the coefficients in the Scobey formula. A glance at table 1 shows that the average values of C_s for grade A pipe, on the specifications as set forth in the text above, vary but little from a value of 0.400, so that our recommendation of a value of 0.370 appears conservative to the extent of 10 per cent. If the designer further protects his computations by adding a quantity of from 5 to 15 per cent to his designed capacity then the formula will probably never yield disappointing results.

Additional data are highly desirable for certain types of the newer construction as listed below:

Jointed pipes made of centrifugally cast concrete without additional interior coating.

Jointed pipe, as made by machines, of semi-wet concrete.

Jointed metal pipes with cement or concrete inner coatings.

Tunnel linings in both round and horse-shoe shapes as placed with a concrete gun against oiled steel forms.

Tunnel or other conduit linings as shot from a cement-gun without forms, but as modified by various smoothing processes.

DISCUSSION

F. F. LONGLEY:⁸ I have listened to what Mr. Scobey has had to say regarding coefficients in concrete pipe lines, with the same keen interest that I always listen to him or read what he writes. His experience has given him a variety of qualifications which fit him especially well to speak on that subject. Not only has Mr. Scobey himself made a great many hydraulic tests on pipe lines of concrete, wood stave and steel, and open channels, with a technique beyond criticism, but he has also gone much further. He has gathered a great deal of information of a similar sort which other folks have produced. He has brought together and correlated all these data. Those relating to pipe lines with interior surfaces of smooth concrete, he has dealt with by themselves, and from them he has constructed a formula of logarithmic order which should prove to be very useful to water works engineers.

True, it adds another formula to the long array engineers already have to keep in mind for ready use, and the question naturally arises whether its value is real or only academic.

⁸ Lock Joint Pipe Company, Ampere, N. J.

The formula which is in most general use today for the flow of water in pipe lines, is the Hazen-Williams formula, also an exponential formula. Its general use is quite obviously due to its recognized dependability and its great convenience through the agency of slide rule and tables.

Mr. Scobey brings out the fact in his paper that his formula and the Hazen-Williams formula do not give the same results. That naturally follows from the differences in the exponents, but it raises the question as to which one really represents the truth. I suppose the answer to that might be that either one closely represents the truth for certain conditions. The Hazen-Williams formula, which was in common use long before Mr. Scobey set out to correlate data on concrete pipe and devise the formula that bears his name, was constructed on the basis of upwards of a thousand observations on pipes of various sorts, largely metal pipes, and intended, as I understand it, primarily to represent the conditions of flow in metal pipes. We cannot doubt that the Hazen-Williams formula closely represents the truth for these conditions.

But, the data upon which this formula was constructed, include only some twenty or so observations on concrete pipe out of more than a thousand. It is, therefore, reasonable to raise the question whether the Hazen-Williams formula does give the true picture of the relationship of the various elements which enter into a formula for concrete pipe surfaces. We may likewise raise the question as to whether Mr. Scobey's formula gives the true picture of the relationship of these elements.

The evidence on this point is the array of hydraulic data relating specifically to concrete pipe, which Mr. Scobey has used in constructing his formula. This includes some two hundred or more observations. These have every appearance of being reliable, and if their reasonable accuracy is admitted, reasonable accuracy must also be acknowledged for the Scobey formula.

There are, of course, always some variations from figures which we take to represent the truth, the composite result of variations in the several factors. The Scobey formula, we might say, represents the center of the target, and the truth for any given concrete pipe line might be on the bull's eye or it might lie within one of the circles.

After one arrives at a satisfying conviction regarding the truth of the two formulae, another question, a very practical one, arises, and that relates to usage. The Hazen-Williams formula has the advan-

tage of extended use by many engineers over a long term of years. Notwithstanding the fact that some other formula such as Scobey's seems to represent the truth more closely for some special set of conditions, the older formula will continue to be used by most engineers as the principal, if not the only one, for pipe line flows. The Hazen-Williams formula is recognized as having a wide general application and within the range of velocities commonly found in waterworks practice, the difference between the results obtained with the two formulae, are not very great, and uncertainties in various factors sometimes obscure these differences.

The Scobey formula applies, of course, to a special kind of pipe line, namely, concrete. There is no evidence that it would represent the truth for steel or cast iron pipe lines, nor does Mr. Scobey claim that it would. The extent of its use is limited by the fact that engineers are already in the habit of using other formulae, giving results which they believe are sufficiently accurate for their need. Also, perhaps, by the fact that there is as yet no slide rule to facilitate its use, although there are convenient tables in Bulletin 852. Perhaps, also, by the fact that engineers, like all humankind, are somewhat reluctant to adopt a new instrument in place of an old and well tried one until some circumstance brings forcibly home to them the advantage of the new one.

The Scobey formula unquestionably has its place in the field of hydraulic studies on concrete pipe lines. Where one wants the greatest degree of precision which the nature of the data justifies, the Scobey formula is indispensable, either by itself or as an adjunct to the Hazen-Williams formula.

I was particularly interested in Mr. Scobey's remarks on the point of difference of workmanship. In the summaries he has made, he states that he has classified the results of his own observations and the studies of others, under three classes, representing the highest grade, a fairly good grade, and a grade that is only moderate. Then, as he says, he throws into the discard the data obtained on very poor surfaces which might be considered as making another grade.

Those who have had experience in trying to build concrete pipe, particularly, I should say, the manufacturers of concrete pipe, know the many difficulties there are in the way of success in getting thorough smoothness. And when I speak of smoothness, I mean not only smoothness of the surface of the pipe wall, but also smoothness of the surface across the finished joint. Only the highest grade of

workmanship, only the greatest pains taken in every step of the processes of manufacture, of laying and jointing the pipe, providing the foundations and all the rest of it, only the greatest care in all of these operations results in an interior surface of this very high degree of smoothness, which, as Mr. Scobey has noted, is present in many pipe lines. Great smoothness is attainable, but it is attained only if workmanship is of the very highest grade.

Mr. Scobey has referred to the high carrying capacity as enduring for a long term of years. There is every reason why it should endure in well made concrete pipe, and there is a reasonable amount of evi-

TABLE 2
Change in coefficients with time

LOCATION	COEFFICIENTS (HAZEN-WILLIAMS) FOUND BY TEST BEFORE AND AFTER THE PERIOD OF TIME INDICATED IN LAST COLUMN		TIME INTERVAL
	Before	After	
			years
D ₁ Siphon of the Umatilla project, Oregon, 30-inch reinforced concrete pipe.....	144	123*	4
Deer Flat Forest pipe line, Boise project, Idaho, 36-inch reinforced concrete pipe.....	121	136	1
R ₁ Siphon of the Umatilla project, Oregon, 46-inch reinforced concrete pipe.....	138	151	3
Denver, Conduit No. 10, 54-inch reinforced concrete pipe.....	141	151	3

* Note from Bulletin 852 page 36: "The values of *C* are probably indicative of the silted condition within a smooth pipe, rather than of the interior surface itself."

dence to show that it does. Among the data in Bulletin 852, three such examples are given in which tests were made upon the same line with a time interval between. One other example is to be found in the hydraulic records of Denver Conduit No. 10. These are summarized in table 2.

The increase in the coefficient in several cases is an interesting phenomenon. I am not much inclined to place any particular significance upon this increase, although there are those who are convinced that it is a real increase resulting from the presence of a thin but very slick inorganic deposit upon the inner surface of the pipe,

after being in use for a time with certain kinds of water. In the one case, noted above, in which there is a diminution, it appears clearly to have been caused by deposits of silt in the pipe.

The really significant thing about all of this is that, barring the presence in the pipe line of foreign solid matter, there is no reduction in carrying capacity. That, after all, is what we are primarily interested in.

If we can lay a pipe line with a high coefficient to start with, and feel a reasonable degree of confidence that we are going to have at least as high a coefficient as that, after the pipe line has grown old, we have a wonderful asset in comparison with the thing we have been accustomed to in the past in building a pipe line, namely, the discounting of carrying capacity and the building of the pipe line oversize with the knowledge that ten or fifteen years later it will have lost a substantial percentage of its capacity. The assumption that engineers have been in the habit of making that their pipe lines were bound to lose capacity after being in service for a time, strikes me like Mark Twain's remark about the weather; "Everybody's cussing the weather, but nobody does anything about it." However, the people who are building high grade reinforced concrete pipe lines today have really done something about it. They are building pipe lines which will continue to give a very high capacity practically as good ten, twenty or thirty years hence, as when they are new.

One of the things that contributes largely to these high coefficients, in my opinion, is the very smooth surface that can be obtained across the joint. Thousands of joints in lock joint pipe lines have been examined for straightness and only the slightest deviations from straight lines have been found. The stream lines in the water flowing over these joints, cannot be anything else but straight and smooth.

A question which has frequently come to my mind is this: What coefficient could we get in a pipe line which we might call ideally smooth? Suppose you had a pipe line in which the surfaces were of such a degree of perfection that it was inconceivable to have them any smoother. What coefficient would you get? We have no practical way of determining that precisely. Perhaps if some enterprising person would build a pipe line with a tube of plate glass, we might get some measurements on it showing us the ideal coefficient. Nobody is likely to do this. The practical question is, how near are we approaching the ideal coefficient now? Those of us who are building pipe lines of this sort today would like very much to have an answer to that question.

Some work has been done abroad in hydraulic studies, which suggests one way of getting some sort of measure of this. It is a work which appears to be but little known in this country. The names of Stanton, Reynolds, Swindin, Parry, appear prominently in some of the writings. The basis of this theory appears to be that friction or resistance to flow in a pipe line depends on two sorts of factors; one, the factors which pertain to the surface of the pipe itself against which the liquid flows; the other, the factors which depend upon internal conditions in the liquid itself, upon density, upon viscosity, upon some of those more or less indefinite things that are referred to as hydro-mechanical inertia.

The origin of these studies was based upon the need that existed in certain industries for more or less dependable facts and formulae for determining the resistance to flow of all kinds of liquids, and especially chemicals of different concentration and under different physical conditions, such as temperature. I am under the impression, too, that the same studies, or studies involving the same principles, have been applied in connection with aeronautics.

But, to come back to the application of all this to our own subject. The relation between the external and the internal resistances have been determined by these English investigators for the flow of water in several different kinds of pipe, brass, drawn steel tubing, lead, etc. I have taken a number of tests in smooth concrete pipe lines and have applied this method of analysis, plotting the points upon the diagram representing the above-mentioned relationship, and find that these plotted points all lie quite close to the curve determined for smooth brass piping.

If we can conclude from such a study that the conditions of flow we are getting in smooth concrete pipe lines today correspond approximately to the smoothness which has been determined for drawn brass tubing in these English studies, it really means that we are attaining a very high degree of smoothness, and that the attainment of anything measurably higher than that, probably is not in the realm of practical possibilities.

I recall a conversation I had some little time ago with Mr. Hazen on the subject of high coefficients in pipe lines. We were talking about coefficients of the general order of 150, more or less, and he remarked that no coefficient higher than 150 had ever come to his notice. With the exception of a number running a few points higher than 150, some reported by Scobey and some obtained in tests on lock joint

pipe lines we have not found any exceeding 150. From all the evidence, it would appear that a pipe line which attains a coefficient of 150 or possibly a few points higher, has reached a practical limit of smoothness which we can hardly hope to excell. I think we can be congratulated today on having at our disposal pipe lines which so nearly approach what appears to be the practical ideal limit of carrying capacity.

one, the factors which pertain to the surface of the pipe which depend upon which the liquid flows; the other, the factors which depend upon internal conditions in the liquid itself, upon density, upon viscosity, upon amount of flow, and so on. These things that are referred to as hydraulic resistance factors.

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A PENSION SYSTEM FOR WATER WORKS EMPLOYEES¹

By L. A. SMITH²

For many years the policemen and firemen in Wisconsin cities have enjoyed the benefits of a pension system, and within the last decade the Teachers' Retirement Fund, affecting all of the teachers in the State, has been adopted. All three of these pension funds have been brought about through action of the Legislature of Wisconsin, but I am reliably informed that under the Home Rule Amendment each city may take appropriate action by ordinance for the establishing and operating of pension systems, not only for water works employees, but for all city employees.

A pension fund is desirable and advantageous both from the view point of the employer and the employee. It is advantageous to the employer for three reasons:

1. It tends to reduce labor turnover. The cost of breaking in a new man is estimated at from one month to one years wages depending upon the importance of the position which he is to fill. A reduction, therefore, in labor turnover will result in much more efficient and economical operation.

2. It eliminates carrying employees upon the pay roll after their period of usefulness is at an end. Practically all large companies, and a great many municipalities, have men upon their pay rolls who have given efficient service for many years, and who, at the present time, are unable to continue to give such service on account of old age. Because it seems unfair and unjust to discharge a man who has given the best years of his life to his employer at the time when it is practically impossible for him to get other employment, many such men are retained on the pay roll, thus increasing the cost of operation.

3. Contented employees, who expect to stay with an organization, render more effective service than employees who are constantly looking for other employment, or are apprehensive as to what their

¹ Presented before the Wisconsin Section meeting, October 11, 1928.

² Superintendent, Water Works, Madison, Wis.

condition will be when their period of active service is at an end. The adoption of a pension system will make for better service because the employee under the pension system does not have to worry about the future.

A pension fund is desirable to the employee for three reasons:

1. Practically all pension funds require a contribution by the employee. This is, in effect, a compulsory saving and is desirable from the employee's standpoint because in many cases he would not save.

2. An employee, under the pension system, receives a bigger return than he would from his own saving, or from annuity insurance because in all such funds there is a contribution by the employer.

3. An employee, under the pension system, looks upon his position as permanent and is enabled thereby, to make permanent arrangements with reference to a home, making his home life more satisfactory, and it is axiom in business that employees with pleasant and stable home life render more effective service than those who cannot make permanent arrangements and are constantly moving. In a great many cases this stability and permanence will enable the employee to purchase a home rather than pay rent, thus bettering his economic condition.

Any proposition which is mutually beneficial to both employer and employee should be adopted. It is my opinion that all cities should adopt a pension system for all employees who are not now covered under the existing systems. For obvious reasons, we, as water works men, should devote our energies to a Water Works Pension System in our cities, but always bearing in mind that other city employees should be similarly treated, and working out, as far as possible, a system which will be generally applicable.

Under the provision of the Police and Fire Pension Systems, the contributions by employees is 1 per cent of the wage, and the pension amounts to 50 per cent of the retiring salary. In the Teachers' Retirement Fund, the employees' contribution is 5 per cent of their wages, and the pension upon retiring varies. In all three of these funds there are various other benefits which are desirable if they can be financed.

Pension funds are sound business because they have been adopted by practically all of the big business organizations, including the American Telegraph and Telephone Company, the Insull group of utilities, and a great many of our large manufacturing concerns, as well as retail business concerns such as Marshall-Field & Co.

Many of these pension systems are worked out in connection with insurance companies.

I had the pleasure, a few weeks ago, of discussing the pension system of the Insull utilities group with the accountant who is working on some proposed changes. In their case the employer contributes either directly to the fund, or to the insurance company which carries the fund. In the public pension funds adopted in Wisconsin, the balance of the fund, outside of employees' contributions, is made up from rewards, fees, fines, insurance premiums and taxes. In planning a pension fund for any group of employees, consideration must be given to their average age, the length of service and the amount of money necessary can be computed very accurately from mortality tables. In working out pension systems it is found that it is not necessary that the pension fund itself be sufficiently great to meet the theoretical obligations because they do not become actual obligations for a great many years.

I believe that a pension fund for water works employees should be as simple as possible, and would make the following specific suggestions:

1. Employees should contribute either 1 or 2 per cent of their salaries.
2. Penalties on delinquent water bills should go into the pension fund.
3. Profit on water works merchandise sales should go into this fund. In both of these contributions, the average water taker is not compelled to contribute and the premium is derived from carelessness in paying bills. The other, profits on materials purchased, is a legitimate source of revenue.
4. A portion of the surplus earnings of the water department should go into this pension fund for the adoption of the pension fund will tend to decrease operating expenses, thus increasing the surplus. A contribution of a portion of the surplus will, therefore, in no way react to the disadvantage of the department or the city.
5. The pension should be based upon 25 years of service—or permanent disability, and amount to 50 per cent of the final wage from the time the man retires until his death.
6. An employee retired after 20 years of service should receive a pension of 40 per cent of his final wage.
7. There should be a pension to the widow of the employee of 50 per cent of his final wage if he is killed in service.

8. For service more than 10 years and less than 20 years, no pension should be given, but his contribution should be returned to him upon his leaving the service, together with interest at 4 per cent.

9. For service less than 10 years the amount of his contribution should be returned to him without interest.

10. The pension fund should be administered by the Pension Board consisting of the President and Secretary of the Water Board, the City Treasurer, the Superintendent and three employees of the Water Department.

11. Employees desiring to go on the pension list should make application to the Pension Board and receive its approval.

12. Employees may be pensioned at any time after they have served the requisite number of years by the Pension Board upon recommendation of the Superintendent.

During the next year I expect to work out a pension system for the employees of the Water Department at Madison, Wisconsin, and at our next annual meeting I shall be glad to give you copies of the regulations which will be proposed, and which I hope may be adopted by that time.

GROUP INSURANCE FOR MUNICIPAL EMPLOYEES¹

By P. J. HURTGEN²

Modern business methods are such an improvement over old ones that we frequently overlook their shortcomings. The business era, through mass production and mass distribution, has resulted in economies which have given many material blessings and comforts to capital, labor, management and the consuming public.

Somewhere in the process of evolution from small business to that of great magnitude, there is too often lost that personal touch between employer and employee on which confidence and good will are based. When that personal touch is gone, when doubt and even distrust replaces good will, then many of the advantages of modern methods are lost. In any business or corporation, and the cities we represent are big business institutions or corporations, the service or results obtained are regulated by the extent of the coöperation among the employees of the various city departments.

No part of a city's business should receive more thought today than the problem of maintaining the good will and coöperation of the employees. The value of public good will has long been recognized and very frequently capitalized.

No plan has done more toward maintaining that personal touch in our city management and securing the loyalty of the employees and the employees' families than has our plan of Employees' Insurance.

Our plan of insurance provides protection for the family of a deceased employee during the period of readjustment following the death of the wage earner. It does away with passing the hat at the death of an employee and puts on a business basis what was formerly taken care of through charity. It provides employees with insurance protection that many could not get otherwise.

Unless your employees are better protected than the average, and I am certain they are not, you will find about 10 per cent that are adequately insured, 30 per cent with inadequate protection and

¹ Presented before the Wisconsin Section meeting, October 12, 1928.

² Director, Public Works, Kenosha, Wis.

60 per cent with little or no protection. The U. S. Chamber of Commerce estimates that 20 per cent of the working men cannot get insurance because of physical impairments.

Employees' insurance is issued without a medical examination, except in a few states whose statutes require a brief medical inspection. Insuring your employees relieves them of some of their worries and creates in them a spirit of coöperation.

The cost of employees' insurance is small: about 3 cents a day per employee, gives each of your employees \$1,000.00 insurance. The exact cost is determined by the average premium based on the age of the employees. The rate of 3 cents per day applies to those employees under 56 years of age. After the age of 56 years is attained, the coverage drops to \$500.00 with the premium remaining the same.

Under the plan effective in Kenosha, heads of departments are entitled to carry $2\frac{1}{2}$ times as much insurance as other employees. In order to procure insurance for your employees, you must interest 75 per cent of the employees to become subscribers to the insurance.

There are several plans of insurance offered by the various insurance companies. The amount of the coverage for your employees should not exceed an amount that can conveniently be financed by the low salaried employees. When the insurance plan was discussed by the employees of our city, it was voted and agreed that all employees who had not attained the age of 56 years would take coverage in the amount of \$1,000.00 and those who had attained the age of 56 years \$500.00, with the understanding that heads of departments could later apply for and receive $2\frac{1}{2}$ times the above amounts, and after the plan went into effect, the department heads who wished the additional insurance applied for and received the additional amount. Under our plan the amount of insurance for which each employee is to be insured is determined by class as follows:

Class 1. Employees who have not attained their 56th birthday, other than department heads.....	\$1,000.00
Class 2. Employees who have attained their 56th birthday, other than department heads.....	500.00
Class 3. Department heads who have not attained their 56th birthday.....	2,500.00
Class 4. Department heads who have attained their 56th birthday.....	1,000.00

However, if the employees in Class 1 had felt able to meet the premium on a \$1,600.00 policy, they would have been free to select

a policy up to that amount, and then in that case, the department heads would have been eligible to insurance up to \$3,000.00.

However, the amount of the insurance must be based on some plan which precludes any individual determining what amount of insurance there will be on his life. This must be determined by the group of which he is a part.

The maximum insurance obtainable for department heads is \$10,000.00, and employees not department heads, \$4,000.00. To obtain these maximum amounts the total coverage on all employees must be not less than \$1,500,000.00 and this amount of coverage could easily be obtained in the large cities where many employees are carried on the pay roll.

Employees who have reached the age of 80 years are not eligible for insurance.

Inasmuch as a man's rating per \$1000.00 insurance at:

25 years of age is	\$0.54 monthly
35 years of age is	0.58 monthly
45 years of age is	0.86 monthly
55 years of age is	1.71 monthly
60 years of age is	2.52 monthly
65 years of age is	3.76 monthly
70 years of age is	5.61 monthly
80 years of age is	12.20 monthly

and if you include firemen and policemen in your group, there is an extra rating of 25 cents per month on each.

As the employees' rating, as a group, will be based on the above average rating, it becomes apparent that the lower the average age of the group, the lower the monthly premium will be, and to bring this rate down to a fair average, especially where there are many old men, it is recommended to give the oldest men half the amount of insurance at age 56, for the need of insurance for an old man is not in proportion to that of the young man, who has responsibilities, such as establishing a home, small children, etc., whereas an old man's responsibilities are mostly confined to taking care of his wife.

In case the employee leaves the employ of the city during the continuance of his insurance coverage, the employee may, if he applies for insurance within 31 days of termination of his employment, be entitled to have issued to him without medical examination and upon payment of the premium for his then attained age, a contract of life insurance in any one of the forms customarily issued by the company, except term insurance.

PERMANENT AND TOTAL DISABILITY BENEFIT

If an employee while insured and before reaching his 60th birthday becomes wholly disabled by bodily injuries or disease, and will be permanently, continuously and wholly prevented thereby for life from engaging in any occupation or employment for wage or profit, no further premium will be collected and the amount of his insurance will be paid to him in a fixed number of installments chosen from the following table.

NUMBER OF YEARS DURING WHICH INSTALLMENTS WILL BE PAID	AMOUNT OF EACH INSTALLMENT PAYMENT FOR EACH \$1,000.00 INSURANCE	
	Annual	Monthly
1		\$85.00
2	\$509.00	43.27
3	345.00	29.33
4	263.00	22.36
5	214.00	18.19
10	116.00	9.86
15	84.00	7.14
20	68.00	5.78

Under the Kenosha plan, a man must have been in the continuous employment of the city for a period of six months to be eligible for insurance and must apply for insurance within 90 days after date of eligibility.

This whole plan of Employees' Insurance is in reality what insurance companies term "Group Insurance." Group insurance can only be written in cases where the employer pays at least two-thirds of the premium. Under existing state laws, few, if any, cities are authorized to expend taxpayers' money for such purposes, this being true in Wisconsin and wishing to give our employees the benefit of wholesale insurance, we organized the Mutual Benefit and Insurance Association of the Employees of the City of Kenosha. Two-thirds of the premium is paid by the employees into the Association, the Association in turn issues to the city a check by the Association's treasurer equal to the two-thirds which the employee is required to pay, and the city then forwards to the insurance company the amount deducted from employees and in addition, a check for the exact amount received from the Association. The entire transaction is handled by the city and thus the employee is put to no trouble whatever in taking care of the premiums.

The City Council by resolution authorized the City Treasurer to receive and disburse these funds as above outlined. In presenting this subject, I have outlined the plan adopted by the city of Kenosha. There are several other plans offered by insurance companies that may fit in better with local conditions in the many cities represented here. Your local insurance representatives can best work out with you the plan that will give you and your employees the best protection for the money expended. You, at least, owe it to your faithful employees to offer them some plan of protection and give them an opportunity to make full use of it if they so desire.

CORROSION OF METALS IN WATER DISTRIBUTION SYSTEMS¹

BY F. N. SPELLER² AND E. L. CHAPPELL³

Corrosion, which is a subject of general interest and economic importance, often becomes one of vital concern to those interested in the distribution of water. Perhaps in no other major industry, unless it be that of the production and refining of oil, do those chemical reactions known as corrosion cause a greater loss and constitute a greater fraction of operating expenses. In many parts of the country the costs of protection against corrosion and replacements due to corrosion losses in water distribution systems are very small, yet in many of those same regions it will be found that other forms of corrosion, such as that of steam return lines become of importance and are likely to be brought to the attention of those responsible for the water supply.

Corrosion, for the purpose at hand, may be considered as the oxidation of a metal by combination with oxygen existing in solution in water. Other forms of corrosion are, of course, known, but by far the more important from the standpoint of the water works men is the one just mentioned. The only other reaction which might be considered of comparative importance is the action of waters containing small amounts of salts and acids in the dezincification of brass which is a serious problem in certain regions. If we limit our discussions to underground distribution systems, corrosion may be practically defined as the rusting of iron.

CAUSES OF CORROSION

The presence of both dissolved oxygen and water is essential for the occurrence of appreciable corrosion. For example, a steel sample

¹ Presented before the Central States Section meeting, August 23, 1928.

² Director, Department of Metallurgy and Research, National Tube Company, Pittsburgh, Pa.

³ Chemical Engineer, Department of Metallurgy and Research, National Tube Company, Pittsburgh, Pa.

will not rust in a sealed jar which contains air-free water prepared by boiling out the air and closing without including air. In a jar containing water, however, to which the air has free access a steel sample is seriously rusted after a day or two and a noticeable amount of rust will form after a few hours in some waters. In practice, water supplies always contain appreciable amounts of dissolved oxygen, unless special means are taken to remove it, so that this, the most important factor in corrosion, can be considered a constant. As corrosion does cause difficulties in certain regions and not in others, although the corrosive agents, oxygen and water, are universally present, we must look to other factors.

Water supplies from different portions of the country vary considerably in corrosiveness, largely because of the different contents of dissolved salts such as calcium or lime salts, silica and silicates, hydroxides, etc. The amounts of these in solution depend upon the character of the water sources and its treatment. Strange as it may seem, the very pure soft waters found in New England are quite corrosive, while in the hard waters found over great portions of the central part of the country, there are sufficient scale forming constituents, such as calcium and silica, to make corrosion a matter of little significance. Those salts in water which tend to form protective scales are mentioned later as means of corrosion prevention, since they may be added to a water in which they are not normally present.

Differences in corrosion rates due to regional or climatic temperature variations are obscured by other much greater variables. On the other hand, when water is heated, as for domestic or industrial uses, its corrosiveness is greatly increased, unless, as in the open type boiler feed water heater, the water is open to the air so that the dissolved oxygen escapes with evaporating steam. Because of this increase in corrosion with temperature, it is desirable to supply hot water at a reasonably low temperature. For example, many buildings supplying hot water at 160°F. have no corrosion trouble, while buildings in the same city using the same water, but at 180°F., find serious corrosion occurring in hot water piping.

CORROSION EFFECTS

Where serious corrosion occurs, the result may be either the choking of the pipe with accumulations of the corrosion product or penetration of the pipe wall. Where the problem is that of choking we have worked out a method for the removal of these rust accumulations, which we have described more fully elsewhere. This method consists

in the solution of the rust by hydrochloric acid to which an inhibitor has been added to protect the pipe. This method is being used for building supply lines, but is rather expensive for large water mains. Where the pipe is penetrated renewal is necessary. For either case it is highly desirable to recognize the corrosive conditions before serious damage has been done, and employ means of prevention if necessary.

As to the proper material for piping, in many parts of the country ordinary galvanized pipe is entirely satisfactory and no special precautions for corrosion prevention need be taken. Preventive methods or suitable materials for one section of the country, however, may be entirely out of place in another. Local experience and practice should always be considered in determining the material to be used with a given water. It is desirable to take into consideration the composition of the water in question and the material found suitable for similar waters in other parts of the country.

Besides the corrosion on the interior of water piping, we have also the problem of exterior or soil corrosion and occasionally the additional factor of corrosion by stray electric currents. The causes of corrosion already discussed hold good for soil corrosions, but the situation is complicated by the additional presence of the soil and the salts which it contains. Many of the failures formerly ascribed to stray electric currents are now believed to be due to ordinary local corrosion. In this connection a very valuable paper, the Bureau of Standards Soil Corrosion Studies, Technologic Paper No. 368, has just been issued and should be given careful consideration by any one interested in the problem of soil corrosion. Some of the outstanding results of this work are the indication that corrosion in soils is very much dependent upon the nature of the soil, but very little influenced by the nature of the metal. This work is partly an outgrowth of the studies of the old committee on electrolysis.

PREVENTION OF CORROSION

Light dips of asphalt paint are frequently used to prevent rusting of certain classes of pipe in transit, but are not expected to give permanent protection. For smaller pipe hot dipped galvanizing has been the standard treatment for years and is entirely adequate in many localities. As pointed out above, local experience will indicate whether galvanizing is sufficient protection for piping in a given community.

Corrosion can be prevented by the removal of the active corroding

constituent, oxygen, from the water as has successfully been done by the use of deaerators and deactivators. These devices have been principally installed on the hot water supplies in individual buildings and where adequately maintained have proven quite effective. The deaerator removes the dissolved oxygen from the water by a system of evaporation and vacuum, while the deactivator allows the dissolved oxygen to combine with scrap iron in a special tank before being fed to the building. Where the water is naturally corrosive it is possible to add suitable chemicals to reduce this tendency. For example, Baylis has reported the use of lime in the Baltimore City water supply with an appreciable reduction in corrosion. We have found it possible by the use of a small portion of sodium silicate in New York City water to greatly reduce the amount of corrosion which occurred in the water supply lines of a large office building and to eliminate entirely complaints of red or rusty water. The problem of water treatment has recently been taken up under the direction of your President, William W. Brush, of New York City, with a view to reducing the corrosiveness of the Catskill water, and we may look forward to interesting results from this work.

The substances commonly added to water to reduce corrosion are, besides lime and sodium silicate as mentioned above, soda ash and caustic soda. It will be noted that besides furnishing material for protective scale as in the case of lime, these chemicals all tend to make the water alkaline. It is in part to this increased alkalinity that their effectiveness is due.

The above methods of water treatment or oxygen removal require attention and supervision, which involves expense and the possibility of neglect. Accordingly one of the most attractive methods of preventing corrosion is the use of protective linings which take care of the problem in the original installation. Two major materials for this purpose have been of interest lately, namely, heavy asphalt mixtures and mineral cements. Cement lined pipe has a long record of satisfactory service, some of the early pipe installed in New England shortly after the Civil War being still in service. Renewed interest in this material has arisen in the last few years, and it is now available for use where a pipe effectively protected against corrosion is desired.

Although asphalt in thin layers has not been found to give permanent protection, yet when sufficiently thick linings are used its service record has been very good. Pipe lined with $\frac{1}{4}$ -inch of an asphalt mastic is now available for distribution lines 6 inches and over. This heavy hydrocarbon lining, besides its permanence, has the advantage of simple handling and installation.

ALGAE CONTROL BY CHLORINATION AT KANSAS CITY, KANSAS¹

By L. B. MANGUN²

It is the purpose of this paper to discuss briefly the problem of algae control in an uncovered distribution reservoir, functioning as a so-called balancing reservoir, the practical results of control by chlorination, and a simple method of applying the treatment.

This reservoir is part of the distribution system of Kansas City, Kansas. It has a capacity of 13 million gallons and is situated about 6 miles from, and at an elevation of 217 feet above, the pumping station. It is connected to the city distribution system by a 24-inch main, through which the water both enters and leaves the reservoir. The reservoir is circular in shape with a diameter of 400 feet, giving a surface area of 125,000 square feet of water varying at different times from 4 to 13 feet in depth, averaging about 8 feet in summer. It is intended to afford not only a reserve supply but semi-automatically to equalize the pumping rate throughout each twenty-four hours, as well as between week-days and holidays. Under normal summer conditions two or three million gallons are used during the daytime and one to two million gallons restored during the night. Consequently, beginning with the reservoir almost full on Monday morning, there is ordinarily a more or less steady loss during the week, so that it usually contains less than five million gallons on Saturday evening. Over the week-end it is attempted to have the reservoir as full as possible again by Monday morning.

Under these conditions the reservoir is constantly supplied with cool water, rich in diatom food, and with turbidity, color, depth and period of storage all very favorable to algae growth. The season requiring measures for algae control is of about five months' duration, from May to September, inclusive. The growth is most

¹ Presented before the Water Purification Division, the San Francisco Convention, June 14, 1928.

² Chemist in Charge, Water Purification, Water Department, Kansas City, Kans.

luxuriant during periods of high temperature and bright sunshine, and the heliotropic action of the diatoms, in conjunction with the liberation of oxygen during growth, gives them the buoyancy which keeps them in constant suspension. This algae-laden water, at times highly impregnated with tastes and odors, formerly was the cause of much complaint in sections of the city which were reached by water from the reservoir.

The method of Moore and Kellerman for algae control by blue vitriol treatment has given fairly satisfactory results under the conditions obtaining in large impounding reservoirs, especially with waters of low alkalinity, but meager success has attended its use in reservoirs of other types. Until recently little attention seems to have been given to methods of control in distribution reservoirs of the kind described above. It has been the common practice to empty the water whenever absolutely necessary, clean, and perhaps spray the floor and walls with blue vitriol solution. By these and similar palliative measures the nuisance was endured until it was ended by covering the reservoir. Thus the problem of algae control in open distribution reservoirs was solved by doing away with the problem itself.

Conditions in distribution reservoirs differ so greatly from those in impounding reservoirs that the same satisfactory results of copper treatment cannot be realized. In the latter a long reaction period is available, only parts near or distant from the point of withdrawal may be treated, and withdrawal may be changed to different depths. In distribution reservoirs there is little possibility of preventing the freshly treated water from entering the mains, the reaction period is short, and though there is a constant change of water, it is not rapid enough to prevent cumulative plankton growth.

Nevertheless, prior to last year blue vitriol was frequently used in this reservoir. Saturday evenings were selected as the time of treatment because the water was low and a given amount of chemical would give the highest concentration, and also because no water would leave the reservoir until Monday morning, thirty-six hours later, by which time the effects of precipitation and dilution greatly reduced the concentration. Tetrastrum was reduced in number but not destroyed under these conditions by dosages as high as 10 p.p.m. The maximum dosage suggested by Whipple for eradicating the hardiest diatom species is 1 p.p.m., and this figure, properly weighted according to the temperature, organic content and alkalinity of this

water, is increased to 1.5 p.p.m. However, in the instance of our most drastic treatment, 10 p.p.m. was administered to this reservoir Saturday, July 3, 1926, when 6,000 tetrastrum per cubic centimeter were present. Twelve hours later it was reduced by dilution to 6 p.p.m., twenty-four hours later the concentration was 4 p.p.m., forty-eight hours, 2.2, and Tuesday morning, sixty hours after treatment, when the water first went to consumers, 1.2 p.p.m. At this time there were about one-tenth as many living organisms as before treatment, which would be the number that dilution alone would give reason to expect. This dosage appeared only sufficient under these conditions to prevent further growth of these diatoms for two days, but not to destroy them.

The limitations upon the use of blue vitriol in any case are such that it should not be considered as a permanent remedy or one that can be continuously used, and since in such a reservoir the necessity for treatment is so frequent, it would be impracticable to attempt to keep the water in good condition by this means at all times, even if far more satisfactory results could be obtained from it than is indicated in the instance cited above.

Following the experiments in 1926, reported by Cohen, with algae control by chlorination in two small reservoirs in Texas, it was concluded to make trial of the method in this reservoir. The immediate problem in this instance was to find a means of chlorinating the contents of the reservoir, which might at any given time be from four to thirteen million gallons of water. The blue vitriol had been applied from a boat, and it was possible to use a floating chlorinating outfit also, as provided by manufacturers for sterilizing small lakes or the larger out-door swimming pools. But the obvious awkwardness of that method in such a reservoir caused a search to be made for something more simple.

The single 24-inch main which connects the reservoir with the pumping plant and distribution system terminates in a well, situated within the reservoir near the wall. This well has three sluice gates, one of which is at the bottom, facing the center of the reservoir. The second, a few feet higher, faces to the right, and the third, the highest, faces to the left. A test showed that the discharge of water to the right from the second sluice gate throughout the night would gradually set up a rotation of the entire body of water in the reservoir such that by morning, when the inflow ceased and outflow began, the water in the reservoir was moving at a rate of 20 feet per minute,

or nearly one complete revolution per hour. A Wallace and Tiernan vacuum type chlorinator had been connected with this main just outside the reservoir for the purpose of treating the out-going water because of high bacteria counts following copper treatment, and also for the purpose of destroying as much taste and odor as possible. It was concluded to use this installation for the purpose of treating the reservoir, by allowing the inflowing water to carry the chlorine solution, and to obtain mixing by setting up the rotation in the reservoir in the manner above described.

Whenever it was desired to chlorinate the reservoir contents, which was done rather regularly about three times a week from July to September during the summer of 1927, the chlorine was fed into the main to the incoming water during the night, beginning about 8 p.m., and at such a rate as would give the total volume in the reservoir the previously calculated dosage by 6 o'clock the following morning. The concentration of chlorine in the inflowing water was ignored, although at times it was undoubtedly as high as 20 p.p.m., and would average 5 p.p.m. In other words, the reservoir water and not the incoming water was being treated. The latter functioned merely as a minor flow for the purpose of treating a larger volume, the sole aim being the application of chlorine sufficient to show a residual in the entire reservoir within ten hours.

A representative treatment was as follows: A dosage of 1 p.p.m. showed a residual of 0.2 p.p.m. by 6 a.m. at the periphery of the reservoir, and 0.02 p.p.m. at the center. While this indicates considerable lack of uniformity in chlorine concentration at a given time, there is reason to believe that all of the water had received nearly equal treatment, for by 9 a.m., and even earlier on a sunny morning, all traces of residual disappear. Of course, the discharge of free chlorine is hastened by photochemical action, but the appearance of the higher residuals is undoubtedly reduced by further diffusion and mixing. Such rapid dissipation of the chlorine indicates also the possibility of considerably augmenting the dosage in case of necessity, or even this dosage could probably be reduced if some means of prolonging contact were employed, such as feeding lime or ammonia with the chlorine.

At the time of the first application of chlorine the reservoir water contained 13,000 synedra per cubic centimeter, and the suddenness of their disappearance following it was almost magical. At no subsequent time have any organisms appeared which have failed to

yield to the treatment, and no objectionable after-effects have been observed. During the entire remainder of the summer not one complaint concerning the water was received from the section of the city served by the reservoir, a new and gratifying experience, indeed, as compared with any other corresponding season since the reservoir was built.

A project for covering the reservoir was under way at the time chlorination was begun. The plans had been prepared for a cover of steel construction with a water-proofed gypsum roof at an estimated cost of \$146,000. In consequence of the results obtained from chlorination these plans have been put aside. No cover will be built if the results of the first season can be obtained indefinitely, or until the capitalized cost of chlorine treatment equals that of the covered reservoir. The cost of chlorination, calculated on the basis of the first season's experience, makes the occurrence of the latter possibility seem so remote as scarcely to deserve mention. The annual cost of operating the reservoir covered would be \$18,522.50, while the annual cost of operating by chlorination is \$1,040.64, which is a saving by the latter of over 94 per cent of the annual cost of operation with a cover, or more than \$17,000 per year. In addition to interest, depreciation, maintenance and operation, these figures include an annual sinking-fund charge for the purpose of retiring bonds, as required by state law, in this case amounting to $4\frac{1}{2}$ per cent. The cost of chlorination includes cleaning the reservoir once a year, as is desirable with the reservoir uncovered, while allowance is made for cleaning the covered reservoir once in ten years. The cover is allowed a lifetime of $33\frac{1}{3}$ years, with the exception of the water-proofing, costing \$13,000, which is given fifteen years.

DISCUSSION

WM. B. SHORT (City Engineer, Anacortes, Wash.): I should like to ask if this water had been previously filtered before it was run into the reservoir?

MR. MANGUN: Yes. This is just a balancing reservoir on the distribution system, after purification of the water.

MR. SHORT: And algae are growing in the reservoir, after the water had passed through the filter.

MR. MANGUN: Yes.

CARL WILSON (Los Angeles, Calif.) We have a case that is perhaps a little more aggravated than the one which Mr. Mangun has just described. We have a reservoir, recently constructed, known as the Ascot Reservoir, covering about 5 acres, and an average depth of something like 70 feet. It is supplied with water that is derived from infiltration, perfectly clear. The reservoir functions as a balancing reservoir on the distribution system. Its capacity is several times the amount of water that passes through it in twenty-four hours. A jar was built, with ports down the center, the incoming water coming in on one side, and circulating, and going out through the ports in the jar, the intake taking in on the other side, in the other half of the jar. That did not produce results, so we put in a circulating pipe, and though it improved matters somewhat, it was, however, not sufficient. We had a growth, a year ago, of *protococcus* of some variety and the water became as green as any you ever saw. Copper sulphate treatment was used in that, as it was used in other reservoirs, daily or weekly, but we could not do anything. The water became greener and greener, and finally we put the reservoir out of service, and used the super-chlorine treatment, which was sufficient to destroy all the growth. We got along very nicely that year; but this year we had a recurrence of the growth, and no amount of copper has controlled it. The water is bad, as to taste and odor, and we have all kinds of complaints about the green water, so many complaints that they run into the hundreds in the course of a day. We are going to try chlorination.

L. H. ENSLOW (New York, N. Y.): I might add a remark to what Dr. Wilson has said, that, in dealing with *protococcus*, we have obtained admirable results by chlorination as compared with copper sulphate.

ARE YOUR WELLS AND RESERVOIRS CONTAMINATED?¹

BY HARRY F. FERGUSON,² AND CLARENCE W. KLASSEN³

Water works men understand that surface water supplies obtained from streams and impounding reservoirs in Illinois are subject to more or less contamination and, therefore, are not clean and safe unless purified. On the other hand, many are inclined to believe that well supplies are safe when they have not yet caused epidemics. The wells and collecting reservoirs in which the well waters are stored are, therefore, not always given proper attention. Wells and collecting reservoirs can be so located and constructed that they will yield continually a clean, safe water. Continuous treatment of the water as it is drawn from wells should not be considered as a substitute for making the water clean and safe at the start.

The contamination of well supplies that has occurred in Illinois during the past few years was such that it could have been detected and prevented or removed by field inspections and analyses, if the municipal officials or waterworks owners had exercised reasonable care and activity in checking such water supplies and in following recommendations made to them. The fact that some well supplies have caused epidemics emphasizes the fact that all such supplies should be carefully and regularly checked by field inspections and analyses and if all possible sources of contamination can not be permanently removed or absolutely guarded against continuous disinfection should be followed to make the supplies assuredly safe at all times.

The engineers and water laboratory staff of the State Department of Public Health are endeavoring to inspect, analyze and report on the sanitary condition and quality of public water supplies throughout the State. Although many defects and possibilities of contamina-

¹ Presented before the Illinois Section meeting, March 29, 1928.

² Chief Sanitary Engineer, Division of Sanitary Engineering, Department of Public Health, Springfield, Ill.

³ Assistant Sanitary Engineer, Division of Sanitary Engineering, Department of Public Health, Springfield, Ill.

tion of wells and collecting reservoirs have been found by such work and have been corrected by the owners of the supplies acting upon the department's recommendations, yet because 379 of the 505 public water supplies in the State are obtained from wells or springs it can not be expected that the limited engineering staff of the department can detect and prevent all contamination of such supplies without the exercise of reasonable care, activity, and judgment on the part of those owning and directly responsible for the supplies.

SOURCES OF CONTAMINATION

We should learn by the experience of others. Therefore, a description of the contamination of wells and collecting reservoirs that have occurred during the past two years in Illinois may interest and stimulate waterworks men owning similar supplies to examine more thoroughly their own supplies.

Contamination of wells may occur at the surface through open tops and may occur underground through defective or leaky casing walls or defective seals at the bottoms of the casings. Contamination of reservoirs may occur at the surface through uncovered tops, through manholes, vents, cracks, etc. in covered reservoirs, and underground through cracks or holes in the sides and bottoms or through drain openings such as have been provided in a few reservoirs.

The contamination of public water supplies that will be described occurred at Morton, Viola, Lockport, Rockford, Sterling, and Marseilles. The Morton and Viola contaminations are representative of surface contamination of wells through open tops; the Lockport of underground contamination of a well; the Rockford of surface contamination of a reservoir through defects in the cover; the Sterling and Marseilles of underground contamination of water stored in collecting reservoirs.

Morton—surface contamination of a well. The Morton supply is obtained from 2 glacial drift wells 35 feet apart, each pumped by a deep-well jack discharging directly into the distribution system. As part of the regular inspections of public water supplies throughout the State, an engineer of the State Health Department reported that both wells should furnish a safe water, *provided* the casings were not defective and that the annular spaces between casing tops and drop pipes were closed. This provision was thus stated because the casings and casing tops could not be observed because they were

covered by the pump bases and, of course, the removal of the pumps as part of the inspection was not feasible. Analyses of samples collected during that inspection indicated that the water from both wells was of safe sanitary quality at that time.

As part of our regular routine sampling of public water supplies, a little later another set of samples was received and analyzed. At that time the samples showed that the water from one well was badly contaminated and from the other safe. Because the previous field inspection and analyses indicated that the water from both

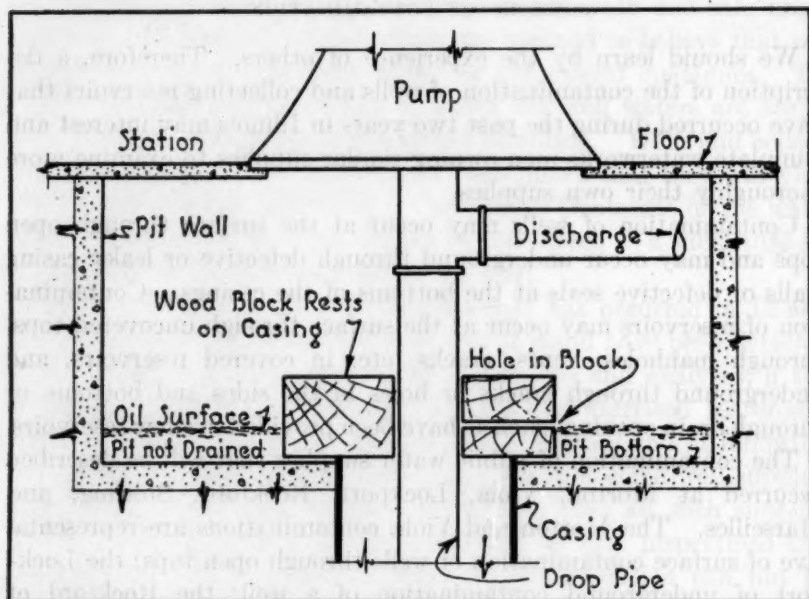


FIG. 1. PUMP PIT AND CASING TOP AT MORTON

wells should probably be of safe sanitary quality, another set of samples was promptly collected and analyzed. These samples again showed one well to be producing a safe water and the other well 35 feet away a contaminated water. The contaminated well was placed out of regular service. Additional samples collected at intervals on seven different days showed that the water from one well was safe and the water from the other was contaminated.

As a reinspection by one of our engineers the water superintendent still considered the tops of the casings, which could not be seen because of the pump bases, were sealed tight, but it was decided to

remove the pump heads and examine the well tops, whereupon it was found that the top of the casing on the well showing contamination was not sealed as had been supposed and that waste pumpage, oil drippings and other dirt were entering the well. The casing top was 18 inches below the pump base and pump room floor and the space between the casing and the drop pipe was open.

While the pump head was off, the drop pipe was removed and 30 gallons of dirty oil, grease, etc. were bailed out. This oil had probably been accumulating on the surface of the water in the well since the installation of the well or for about thirteen years. From the amount of oil and size of casing and drop pipe it is estimated that the upper 26 feet of the "water" was dirty oil. The accumulation was finally sufficient so that when the water level in the well dropped during pumping some oil was drawn in through the bottom of the drop pipe and analyses showed contamination.

The city took steps immediately to seal the casing top and to make provisions so that waste water and oil drippings would not drain around the casing. The drop pipe was scrubbed with chlorinated water, replaced, and the well again put into service. A series of analyses of samples collected following these improvements and a pumping of the well to remove the old contamination, showed that the well was producing a safe water.

The Morton water supply problem is a splendid example of the value of regular sanitary analyses of well supplies.

Viola—surface contamination of a well. Another interesting example of analyses revealing the cause of pollution of a well supply is found at Viola, a small village whose water supply is obtained from one deep drilled well, pumped by a deep-well jack discharging directly into the distribution system.

Inspection of this supply by one of our engineers indicated that the well should yield a water of safe sanitary quality. Analyses of samples collected during the inspection confirmed the result of the inspection. Routine samples were regularly received and one and one-half years later a set of samples indicated the water from the well was badly contaminated. Two more sets of samples confirmed these results.

At first inspection the annular space between casing top and drop pipe was tightly closed, but some time following the inspection repairs on the well were made and at the reinspection of the supply, following the bad analyses, the annular space was found to be closed

only by a block of wood 12 inches square and 8 inches thick which rested on casing top and through which the drop pipe extended. The superintendent of water believed that this board adequately protected the casing top which was flush with the floor of the pit below the pump. A hole bored in the side of this wood block and 3 inches above the pit floor acted as an air release when the well was "recovering" after pumping. The pit was not drained; it contained oil, waste pumpage, etc. to a depth up to the hole in the wood block. The pumping station man stated that since the wood block was installed it never had been necessary to pump accumulated water

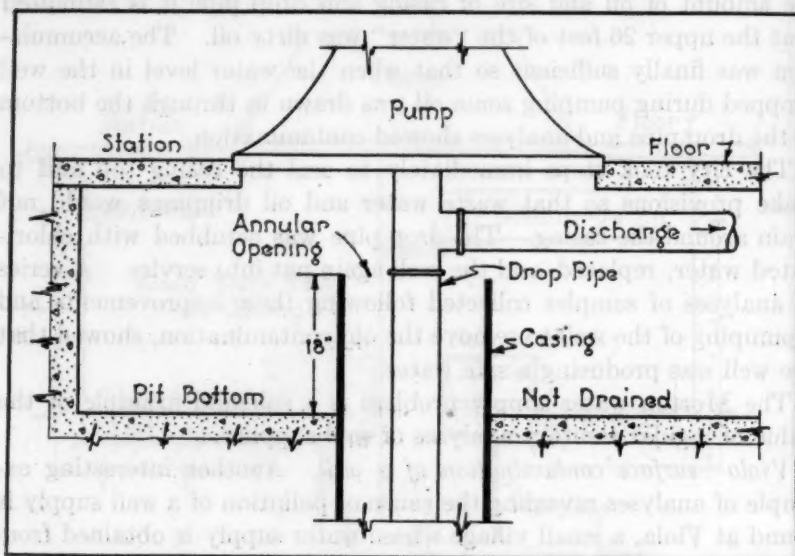


FIG. 2. PUMP PIT AND CASING TOP AT VIOLA

and oil from the pit as previously was the case. This was evidence that the waste water and oil passed into the well through the hole in the wood block and maybe at other points around the top. Upon removal of the pump and drop pipe, 10 gallons of oil, grease, etc. were removed from the well. The drop pipe and inside of casing were cleaned, the well chlorinated, pump replaced with annular, sealed and good analyses followed.

Lockport—underground contamination of a well. A recent case of pollution of a new deep well furnishing part of the Lockport public supply serves as an excellent example of wells becoming contaminated underground.

This well, which was put into service in August, 1927, is 1,470 feet deep ending in Potsdam sandstone. The upper formations penetrated were 15 feet of filled-in soil which included much rubbish, cans, etc., then creviced limestone with numerous joints and solution cavities to 240 feet, then 115 feet of Richmond shale to a depth of 335 feet and then a Galena dolomite formation 295 feet thick. The well is cased with 16-inch diameter, wrought iron pipe for the upper 363 feet and seated 8 feet into the dolomitic formation where a marlin packer was supposedly placed so as to prevent shallow ground water running down the outside of the casing and into the well. The casing was set in a 19-inch diameter drill hole, the upper 9 feet of which has a drive casing which was not removed after drilling. The annular spaces between the drive casing, the 16-inch casing and the walls of the drill hole were not filled.

The annular space between the casing top and drop pipe was not closed.

On January 27, 1928 several consumers complained of a "gasoline" taste in the water and the following two days numerous complaints were received and the water was stated to have such an objectionable taste as to make it unfit for drinking. Odor of the water was similar to that of a cleaning establishment near the well. Tanks where the Stanasol, or cleaning fluid, is stored were inspected for leaks but no seepage from underground tanks could be detected. The sewer from the building to the street sewer was then uncovered and at a point about 40 feet from the well a break in this sewer line was found from which waste water and used cleaning fluid was entering the ground and seeping through the creviced limestone into the drill hole of the well.

Examination of the well by one of our engineers indicated that the cleaning fluid had accumulated on the surface of the water in the drill hole around the casing. Further investigation showed that during pumping and "recovery" of the well the water level in the drill hole around casing and water level inside the casing fluctuated together. This proved that there was some direct connection between the spaces around and inside the casing, a condition which of course should not exist. This connection was further substantiated when fluorescein was placed in drill hole around the casing and after one-half hour pumping the water discharged from the well had a strong green color.

There were three possibilities of a connection between the water

in the drill hole around the casing and that inside the casing namely:
 (1) crevices connecting the upper and lower limestone strata (2)

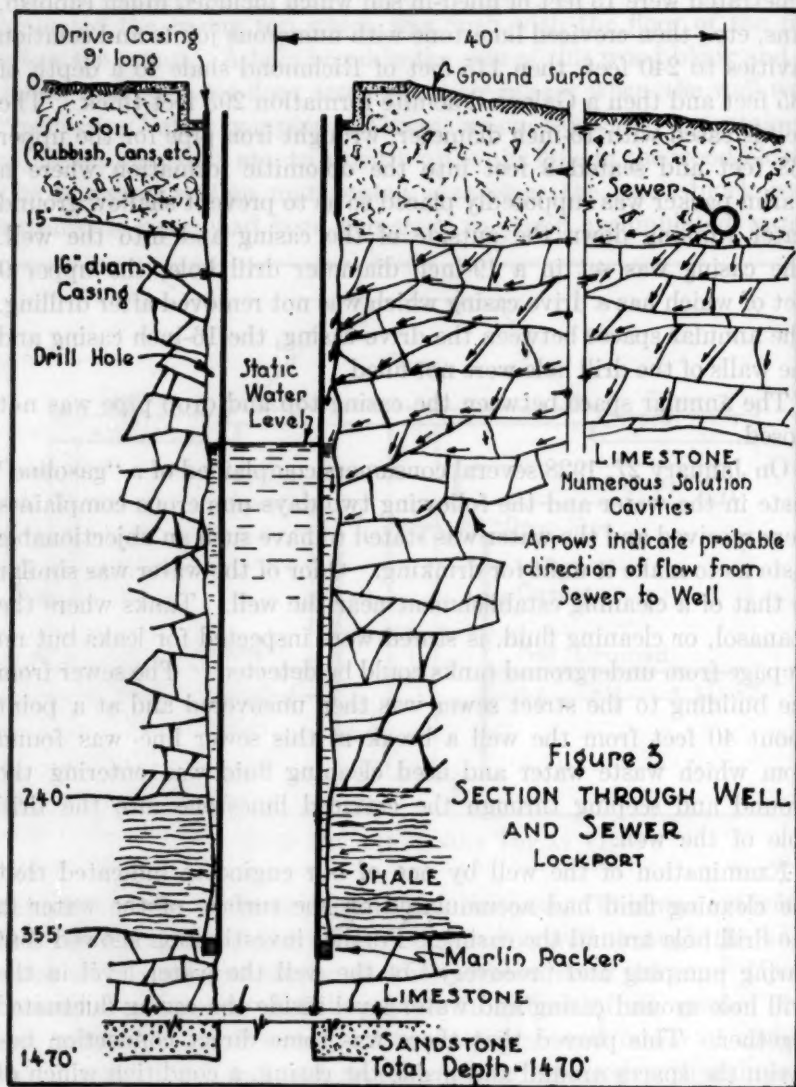


FIG. 3

defects in casing walls and (3) seepage through the marlin packer at the bottom of the casing.

The possibility of crevices existing so that water from the upper

creviced limestone could pass through the Richmond shale into the lower limestone is remote inasmuch as 115 feet of shale separates the two limestones and according to the State Geological Survey the lower limestone is of very dense structure with very little likelihood of crevices.

The fact that when fluorescein was added to the outer hole, the color did not gradually appear as would be the case if merely slow ground seepage was occurring or a small defect in the casing wall existed, but appeared suddenly indicated a rather large direct connection. The simultaneous lowering and rising of water levels both inside and outside of casing further confirmed that opinion. All evidence points strongly to a defective or possible absence of packer where the casing is seated in the second limestone. With this condition existing contaminated shallow ground water could easily find its way into the drill hole and thence into the well.

Located 30 feet distant and at an elevation higher than the well, is a pit privy with a shallow vault in the earth. Had this defect in the well below ground not been found, it is reasonable to suppose that the privy vault and seepage from sewers would have been continually drained into the well, seriously contaminating the supply and possibly causing an epidemic.

Rockford—covered reservoir contamination. Rockford's main supply is pumped from several St. Peter and Potsdam sandstone wells into a concrete reservoir having a heavy concrete cover. Inspections and analyses by the Rockford Health Department have shown unquestionably that the water is intermittently contaminated through improperly constructed and not water-tight manhole openings and covers. Most of these openings are built with slightly raised sides with perforated covers. One large opening had the cover flush with the reservoir top and was so located that at times of heavy rains or melting snow-water the rain or snow-water with accumulated street dust, bird droppings, etc. entered the reservoir.

Sterling—underground reservoir contamination. The Sterling-Rock Falls supply is obtained from 4 rock wells which discharge into 3 circular collecting reservoirs from which the water is pumped into the distribution system. Until recently the wells were flowing, hence keeping the reservoirs full practically all of the time.

The reservoirs are located on low ground, which is partially cinder filled, several hundred feet away from Rock River. One reservoir is about 3 feet from an open pond formed by excavation and embank-

ment, which is fed by reservoir overflows and surface water. The reservoir walls extend several feet above ground surface, and are covered by conical frame roofs. No accurate information could ever be obtained by our engineers relative to the construction of these reservoirs, except that they were 30 feet in diameter, 12 feet deep, and walled with stones supposedly laid in cement mortar. The reservoirs have been in service for a number of years, the water company changing hands several times, and each new manager taking for granted that the reservoirs were contamination-proof.

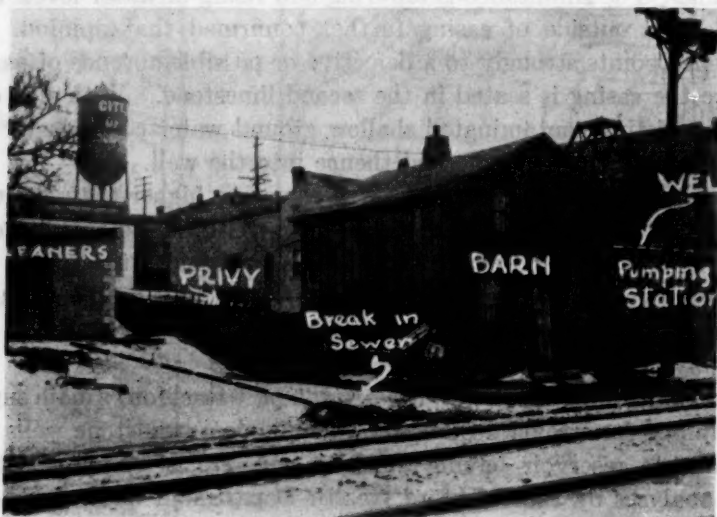


FIG. 4. LOCATION OF WELL, SEWER BREAK, ETC., LOCKPORT

Recently it was necessary to drain the reservoir adjoining the pond in order to make repairs on a valve located under water on the reservoir floor. When the reservoir was emptied it was discovered that the walls allowed considerable seepage of shallow ground water, a great amount of which no doubt was coming from the open pond. At the same time the seepage was noticed, a more startling discovery was made. The reservoir had an earth bottom, a condition of which the present owners were totally unaware. The stone masonry walls had been built on a clay foundation which also served as the reservoir floor. While this condition may be a bit unusual it must be remembered that the water superintendent has taken for granted that this reservoir was protecting the supply

against being contaminated. Incidentally a few analyses had shown slight contamination.

If the persons responsible for that water supply in the past had been determined to know just how the reservoirs were constructed and had investigated them, the condition of the reservoirs that have endangered the quality of that supply for more than thirty years and made the company liable for any illness resulting from water-borne epidemics during that period would have been corrected. Fortunately the operation of the plant was such that the reservoirs were nearly full at all times, but had the water level in them been

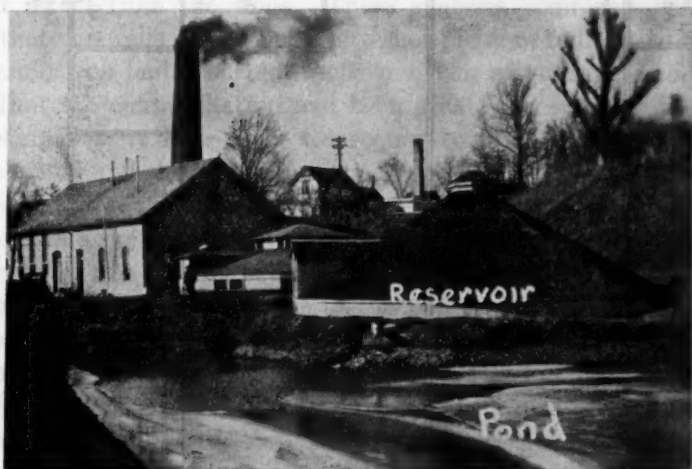


FIG. 5. LOCATION OF RESERVOIR, STERLING

drawn down, especially at times of flood flows in Rock River, no doubt serious pollution would have taken place as at Marseilles this year.

Marseilles—underground reservoir contamination. The Marseilles supply is obtained from 2 flowing wells, ending in Potsdam sandstone, one located along a power race connected to Illinois River, and discharging into a concrete collecting reservoir through the bottom of which extends the other well. Water is pumped from the reservoir into the distribution system.

The reservoir is 50 by 17 feet in plan, 16 feet deep, and so located that one concrete wall serves as part of the wall of the power head race and the top serves as the pumping station floor.

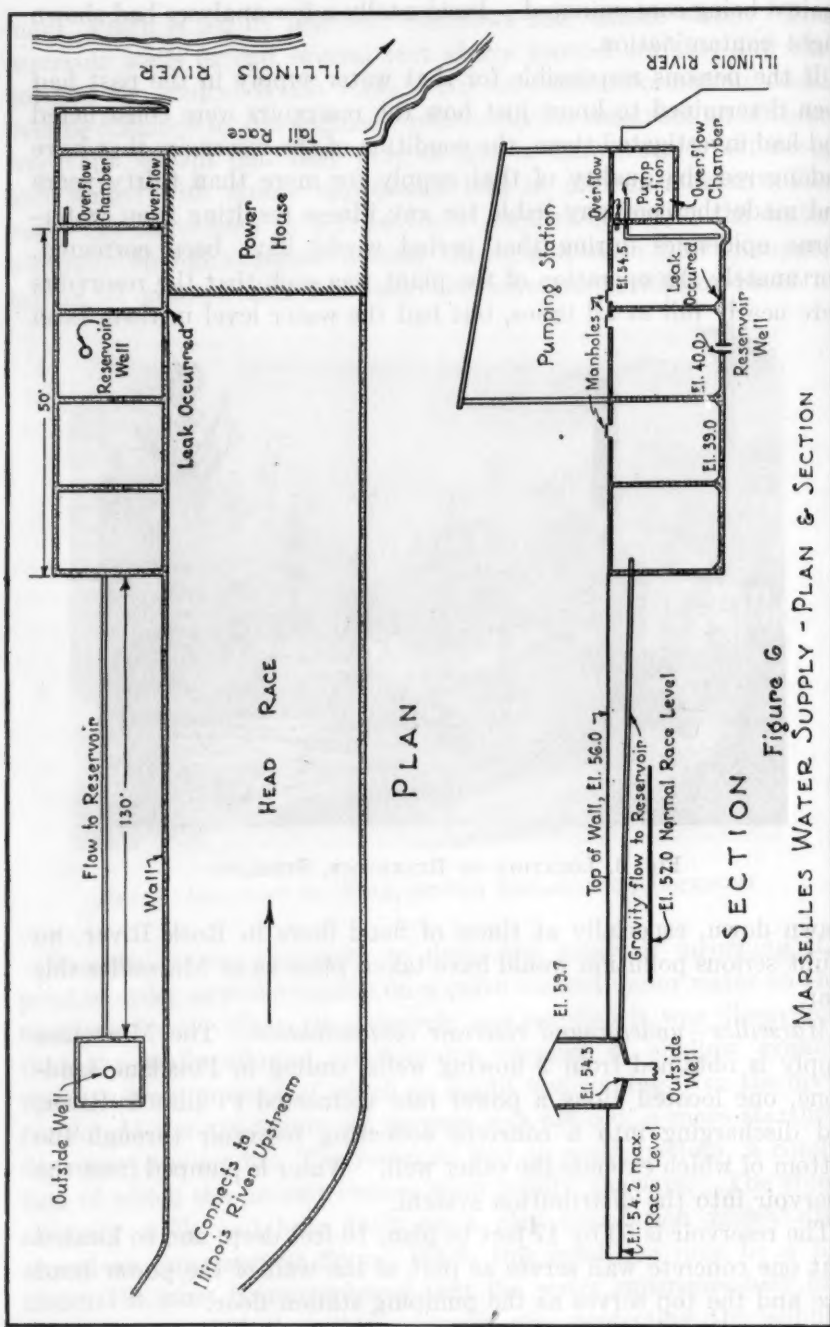


FIG. 6

On January 6 an epidemic of dysentery broke out which affected about 700 persons, and lasted several days. The explosive character of the illness, the geographical distribution of cases, the fact that epidemiological study showed no food or drink in common other than the public water supply, indicated that the public supply was probably the cause, although those in charge of the water supply had considered its quality safe.

Analyses of samples collected by our engineers at the start of the epidemic indicated gross pollution of the water in the mains, somewhat less pollution of the water direct from the reservoir and a safe water direct from the wells. These analyses combined with the fact that the wells flowed under artesian pressure indicated that the contamination had occurred in the reservoir after leaving the wells and that the contamination had been greater previous to the time the samples were collected. Consequently the flow from the wells was shut off and the reservoir pumped dry.

Inspection of the emptied reservoir revealed a hole at the bottom of the wall adjoining the power race through which polluted Illinois River water was flowing in a one-half inch stream into the reservoir. Although there is no doubt as to the pollution of Illinois River at Marseilles, in order to have analytical confirmation a sample of the water flowing through the hole was collected and analyzed. It was highly polluted.

The amount of pollution which entered the reservoir was, of course, dependent on the difference in water levels in the head race and reservoir. With the level in the reservoir equal to or above that in the race no infiltration occurred, but as the reservoir level dropped below the race water level the head or pressure causing inward leakage correspondingly increased. Where the polluted water actually entered the outside of the wall is not known, for a crack allowing seepage may extend several feet either way from the hole on the inside and through which polluted water was actually entering. The reservoir was struck by lightning in August, 1927, approximately above the location of the leak. This may account for the crack and hole. The lightning may also have melted the reinforcing leaving an interior hole.

The water company stopped the leak by caulking the hole from the inside with lead wool, and placing concrete over it. How long this method of repair will exclude polluted water is uncertain. The water is now being chlorinated continuously.

Because the amount of polluted-water infiltration depended on differences in water levels in the reservoir and head race, data were collected to compute this relation for all hours just preceding and during the epidemic.

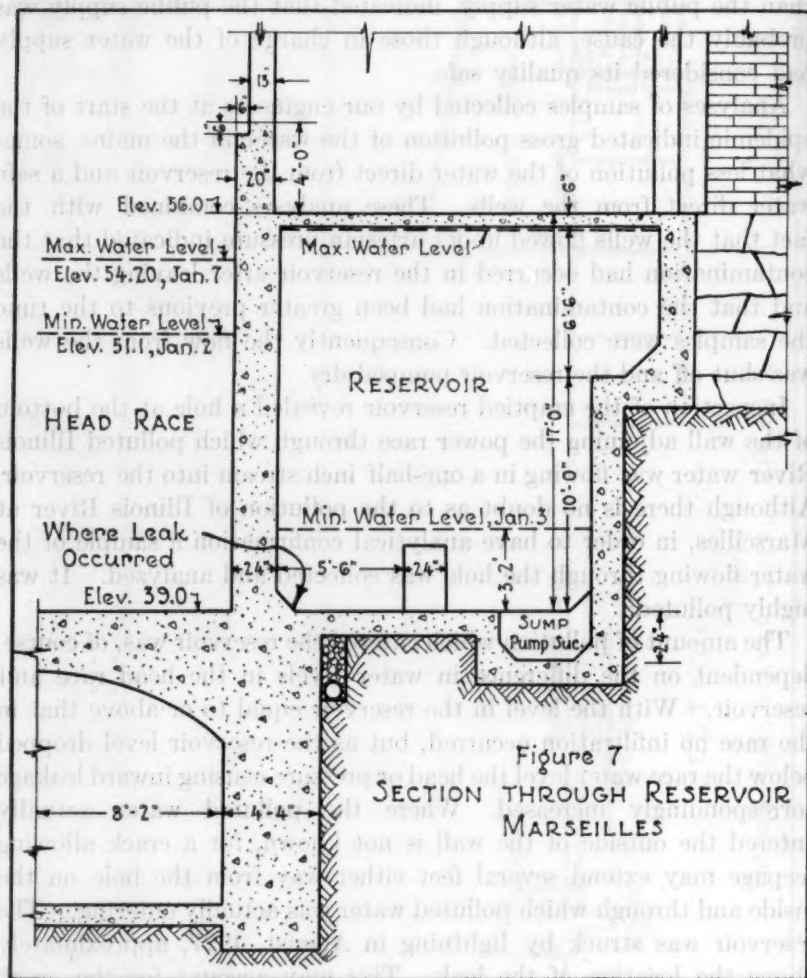


Figure 7
SECTION THROUGH RESERVOIR
MARSEILLES

FIG. 7

Computing the flow from the wells and knowing the rates and time of operation of the service pumps, the mass reservoir inflow and outflow (pumpage) diagrams were drawn. From these mass diagrams the amount of water in the reservoir at all hours was deter-

mined and knowing the area of the reservoir, a curve showing water levels for all hours during January 1 to 9 was drawn. Gauge readings from the water company records gave the water level in the head race. An ice jam in Illinois River just previous to the epidemic caused the water in the power race to stand about 2 feet above normal stage.

The water-level curves showed that for 76 per cent of the nine-day interval, January 1 to 9, there was a head causing inward leakage of polluted race water. From 7.40 a.m. January 3 to 6.30 a.m. January 5, or for forty-six hours and fifty minutes, there was a continual head, causing inward leakage of polluted race water. Two

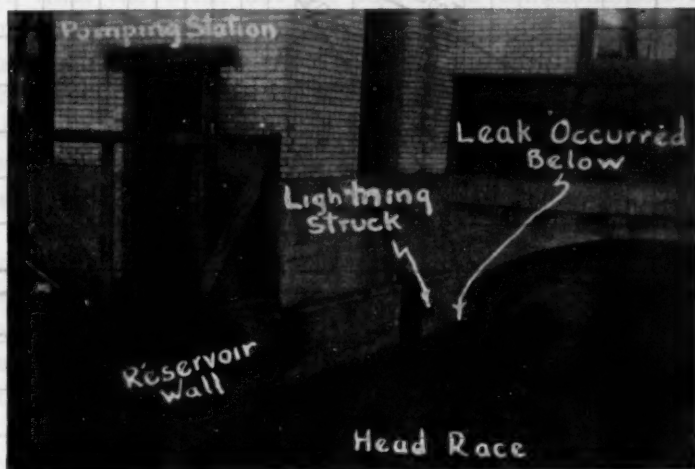


FIG. 8. HEAD RACE, RESERVOIR WALL, ETC., MARSEILLES

other periods, each of nineteen hours, occurred during January 6, 7, 8 when no doubt more polluted water entered the reservoir. It was concluded that the pollution of the public water supply causing the epidemic occurred during the above mentioned forty-six-hour period of inward leakage, pollution first entering during the morning of January 3, with the peak occurring at 3 p.m. on that day at which time the pump was stopped after it had been operating for eight hours continually and the water level had been drawn down to within 3 feet of the reservoir bottom. This was about forty-eight hours before the epidemic started. At no other time during the nine-day period did the pump operate for so long continuously.

The reason for the high consumption at that time is not definitely known, but it is interesting to note that it corresponds with the date on which the United States Weather Bureau recorded the lowest

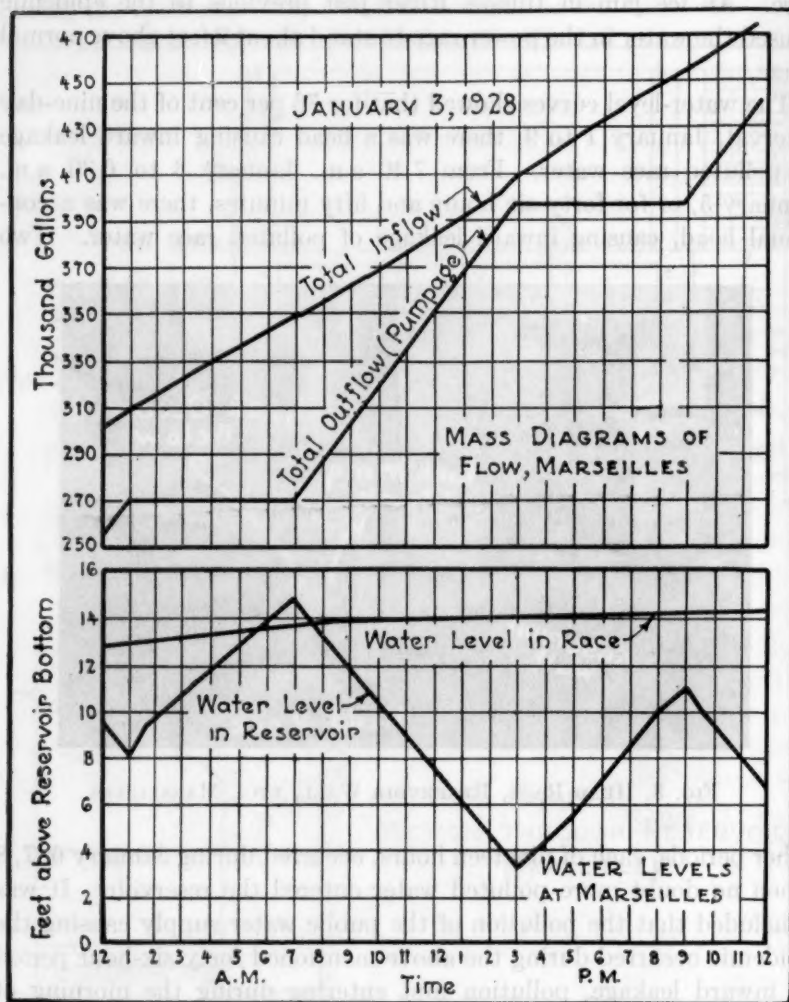


FIG. 9

temperature (-8°F.) for that district during the first nine days in January. This very low temperature may have caused many consumers to allow water to run in order to keep pipes from freezing.

As stated in the first part of this paper many defects and pos-

sibilities of contamination of well supplies have been corrected by the owners acting upon reports and recommendations made by the Engineering Division of the State Department of Public Health. Other supplies are known to be still subject to contamination, because of defective wells or collecting reservoirs and undoubtedly there are some possibilities of contamination that have not yet been detected and reported upon by the Engineering Division. Therefore, a thorough physical examination of wells and collecting reservoirs should be made by waterworks superintendents supplemented by routine bacterial analyses. There are also some public water supplies that are obtained from wells, which are of good quality as drawn from the wells, but are subject to contamination in uncovered or improperly covered reservoirs.

The fact that a well supply has been used for many years and has not yet caused any water-borne illness is not proof that the supply is not subject to contamination. Nearly all of our water-borne epidemics have been caused by supplies that were locally thought to be safe, but which were subject to contamination. It is only a question of time before a dangerous type of contamination occurs and causes illness among the consumers. All kinds of contamination will not cause illness among the consumers, but it is reasonable to assume that where and when avenues for any kind of contamination are open, dangerous contamination may occur at any time under certain conditions.

If owners of public water supplies overlook, because of lack of inspection, or permit any kind of contamination to continue for financial or any other reason, then such owners are not exercising *reasonable care* and, therefore, would be liable for damages for any illness that might be caused by such supplies in accordance with recent court decisions.

SURFACE WATER FLOW IN INDIANA¹

BY DENZIL DOGGETT²

In 1919 the Department of Conservation was organized for a more efficient administration of the several state boards of Entomology, Forestry, Lands and Waters, Geology, Fish and Game.

In 1921 the Division of Engineering was organized as a separate Division, and in the Act which provided for this Division there was an outline of its duties. One of these duties was the collection and dissemination of statistics.

In connection with its duties relating to the collection and dissemination of data and statistics, the Division of Engineering of the Department of Conservation started a stream gaging program in 1923.

The amount of water that flows in the various streams of the state at different times and seasons of the year is important in the complete development of the state's resources, both agricultural and commercial. Data on this subject are necessary in the planning of reclamation works, in the design of water power, water supply and sewage disposal works and in the study of stream pollution.

Our work in regard to stream gaging has been limited in scope due to lack of funds for this particular activity. We have had other work to carry on and the stream gaging work has necessarily been limited to our spare time.

The stream gaging program was inaugurated in 1923 and has grown steadily by the addition of a few stations each year until, at the present time, we have more than twenty stations from which full time records are available. These stations are distributed over the state as follows:

Five on the Wabash River,
Five on the West Fork of White River,
Two on the East Fork of White River,

¹ Presented before the Indiana Section meeting, March 15, 1928.

² Assistant State Engineer, Department of State Conservation, Indianapolis, Ind.

Two on the Kankakee River,

One on each of the following rivers: White, Whitewater, Upper Eel, Lower Eel, Tippecanoe, Mississinewa, Salamonie, Elkhart.

We have to rely largely on reliable coöperating agencies for our gage readings. Among these agencies are water companies, power companies and the United States Weather Bureau.

In the distribution of these stream gaging stations, the flow of all streams in the state are not measured. It has been our aim to cover those representative streams which would be of the most value to the greatest number of industries, agencies and individuals. The flow of surface water from practically all types of topography and different shapes and sizes of drainage areas are tabulated. From this information, those persons not located on a stream served by a gaging station, may take into account the conditions which govern their stream, pick out the measured flow of a stream which parallels their condition and arrive at a remarkably accurate estimate of flow for their given condition.

As our funds permit, it is our intention to extend the scope of our program to cover smaller areas of still further differing types of topography so that a still greater number of industries and public works may be benefited.

One of the essential things which is lacking in the adapting of stream flow records of one area to another, is adequate United States Geological Survey topographic maps of the state. Practically none of the state has been mapped while the mapping of all the states around us is practically completed.

Briefly, the establishment and maintenance of a station is carried forward as follows:

A site is selected so that the level of the pool (which controls the gage height) has a permanent control. If possible, this site is located so that a chain and weight type of gage may be installed on a highway bridge, if not, a staff gage is installed. This same bridge is also utilized as a place from which a current meter may be operated to secure velocity determinations. A gage reader is secured locally to take daily gage readings of the water level in the stream.

A rating curve for the stream is compiled from the velocity determinations taken at varying gage heights ranging from the lowest to the highest. These velocity determinations are taken over a period of several months or even years. Velocity determinations are made periodically after the rating curve is completed as a check on the accuracy of the curve and the permanency of the control.

After it has been determined that the curve is accurate, a rating table is compiled for all gage heights from the lowest to the highest. This table is made by entering the rating curve with the various gage heights represented at the static and tabulating a discharge for each gage height. These gage heights vary from one another by a hundredth of a foot.

After this rating table is compiled, a compilation of the daily discharges of the station in second-feet is made by entering the table with the daily gage heights.

With unchanging conditions of control the above table remains accurate for the various gage heights read by the observer and is used until conditions force us to make a revision.

The Water Resources Branch of the United States Geological Survey has evolved standard methods for all phases of stream gaging work. Our activities in this work are all patterned after these standard methods so that we feel that our accuracy is on a par with that of the federal governmental agency.

In the tabulation of stream flow data, we endeavor to put them in a form which can be used by the greatest number of people. General information is given regarding the location of the gaging station on the stream, the drainage area represented, the type of gage, the place of making current determinations, the condition of channel and control, accuracy of records and the extremes of discharge at the station.

Tables are compiled giving daily discharges for the station over the period from the establishment of the gaging station to the present time. A table is also compiled of the monthly discharge in second-feet for each year covering the maximum, minimum, mean, and "per square mile" discharges for each station. This same table also gives the run-off in inches of depth for the drainage area.

Any of the discharges (which are given in cubic feet per second or "second-feet") may be reduced to gallons per minute by multiplying by the factor 448.83 and to gallons per twenty-four hours by multiplying by the factor 646, 317.

Elements which enter into the accuracy of records at gaging stations are the shifting of the control of the pool, on which the gage is located, regulation due to the operation of power plants and diversion by water companies, ice formation in winter and the growth of vegetation in summer. In locating gaging stations, we endeavor to find stretches of the streams which are not affected adversely

by any of the above artificial elements of inaccuracy. Records must be free from these to be of the utmost value.

Copy has just been completed for a publication which will contain all of the data which we have compiled since the inauguration of our stream gaging program in 1923. These data extend up to the end of the past fiscal year which ended September 30, 1927. This publication should be available by May 15. In case data are desired for dates later than that given above, we are prepared to furnish blue print copies of them.

We hope that the data contained in our publication may prove to be of service to the engineers and scientists who are interested in the planning of reclamation works, in the design of water powers, water supplies and of sewage disposal works and in the study of stream pollution.

DISCUSSION

JOHN C. DIGGS.³ This survey of water flow is something we have needed for a long time. All of you have had experience in measuring water in small quantities, but in case of measurement of streams it is a different matter. It is very interesting and very important. But so far there has not been much experience and only individual efforts. We have records only for a few weeks, months, and years in any particular stream. Very often these measurements are not correlated with the measurement of watershed areas. The determination of the rate of flow is, of course, of great value in the work of flood prevention, and the total annual run-off in case of power or water supply. The measurement of minimum run-off is necessary in reference to the proper dilution of sewage or to determine to what extent the stream can care for sewage or trade waste. We should have a stream flow of about $4\frac{1}{2}$ cubic feet per second to take care of a population of one thousand, and that does not take into account the condition of the water for use in dilution purposes, as the water may not have the capacity of oxidizing organic matter in the sewage. It may be loaded with organic matter so that it cannot take care of more where we have sewage which has a high oxygen demand, so that 20 per cent of it would be oxidized during the first day after it is discharged into the stream. We must have water with sufficient oxidizing material in it to convert the material.

³ Sanitary Engineer, Department of Conservation, Indianapolis, Ind.

THE DIFFERENTIATION OF THE COLI AND AEROGENES GROUPS OF BACTERIA¹

By A. J. SALLE²

In recent years far greater importance has been attached to the separation of the coli and aerogenes divisions of the colon groups than heretofore. Rogers (1) (2) (3) and his associates showed many years ago, by a study of the gas ratios and final hydrogen ion concentration of many colon cultures, that the natural habitat of *B. coli* is the intestinal tract of man and animals. On the other hand, *B. aerogenes* is rarely found in human and animal excreta, but is predominantly a soil or grain type of organism. Therefore, these two groups of bacteria are no longer believed to have the same sanitary significance in passing on the potability of a water supply.

Unfortunately under many conditions a clear-cut differentiation of these two divisions with the identification of the organisms is a difficult and long procedure. In order that this may be more easily achieved, certain disturbing factors must be eliminated or removed as far as possible, such as (a) aerobic and anaerobic spore formers capable of producing acid and gas in lactose broth and (b) bacterial symbiosis or synergism.

Michaelis and Marcora (4) and later, Clark (5) showed that the final pH for cultures of *B. coli* are a physiological constant. This work was, also, extended to include *B. aerogenes*. By means of a simple medium conditions were established whereby the metabolism of one group was made to diverge very far from that of the other, resulting in a distinct difference in the final hydrogen ion concentration produced by these two main divisions of the colon group. This test is known as the methyl red reaction (6) (7). Other well known methods which have been used for the separation of the two divisions of the colon group are the Voges-Proskauer (V.-P.) (8), uric acid (9) and citrate tests (10) (11).

¹ Presented before the Water Purification Division, San Francisco Convention, June 13, 1928.

² From the Bureau of Sanitary Engineering, California State Department of Public Health, and the Division of Bacteriology, University of California Medical School, Berkeley, Calif.

Of the solid media now in use, the eosin-methylene blue (E.M.B.) agar of Holt-Harris and Teague (12), as modified and simplified by Levine (13), is probably used more than any other. Even on this medium there are strains of coli and aerogenes that give a doubtful reaction. Endo medium (14) and its many modifications by Kendall and Walker (15), Kendall and Day (16), Kinyoun and Deiter (17), Harding and Ostenberg (18), Robinson and Rettger (19), and Levine (20), adapting the medium to various problems, have been used. Unfortunately this preparation is very poor for a good differentiation of the coli and aerogenes groups. Where a separation is required this medium is not generally favored. Simmons (21) has added agar and brom-thymol-blue to Koser's citrate medium and has reported excellent results.

The principle of the methyl red test of Clark (6) (7) has been made use of by the writer (22) in the form of a solid streaking medium. The agar is composed of erythrosine, methylene blue and brom-cresol-purple incorporated in a lactose agar base. There is present sufficient lactose to satisfy the carbohydrate requirements of *B. coli* but insufficient for the needs of *B. aerogenes*. As a result, *B. coli* will grow and produce sufficient acid to change the color of the brom-cresol-purple from purple to orange or yellow, and at the same time produce a metallic sheen to each colony. On the other hand, *B. aerogenes* will not produce its maximum acidity, due to insufficient lactose and, therefore, produce neither a change in the color of the agar nor a metallic sheen.

This medium has been in use for a period of about two years and has produced excellent results. Previous to its adoption Endo agar was used with the result that it was very difficult, if not impossible, to differentiate the intestinal and grain or soil types of the colon group.

At the time this work was carried out it was not appreciated that different brands of dyes or even different lots of the same manufacturer's product could vary so in their physical and chemical properties. It makes very little difference which brands of methylene blue and brom-cresol-purple are used but the difficulty lies in the erythrosine. With the exception of a small quantity of pre-war erythrosine on hand at the time and one lot made in this country, no other brand has been found satisfactory.

Work was accordingly started in this laboratory on the preparation of a satisfactory erythrosine with the result that a product has been

developed that is far superior to any of those tested, and which has given excellent results. This work will be published in a later paper.

FALSE PRESUMPTIVE TESTS

Not all organisms which ferment lactose with the production of acid and gas are members of the colon group. This phase is still occupying the minds of investigators to find methods for the elimination of these disturbing factors in routine water examinations.

Frost (23) reported that many positive presumptive tests were due to obligate anaerobes present capable of fermenting lactose. A Gram negative spore-forming anaerobic bacillus giving gas in lactose was isolated by Meyer (24). Ewing (25) was able to isolate a similar organism which gave false results. Hinman (26) found that 80 per cent of the positive tests given in lactose broth were not due to members of the colon group. More than 90 per cent of false presumptives was reported by Raab (27). On the other hand Meader and Bliss (28) were able to isolate anaerobes in only 21 per cent of the samples studied and concluded that such organisms have been an unimportant factor in the fermentation of lactose.

BACTERIAL SYMBIOSIS

A phenomenon which occurs commonly in water examinations and which is responsible for many non-confirmatory tests is known as bacterial symbiosis, or the association of two or more organisms for mutual benefit. The importance of this phenomenon was pointed out by Sears and Putnam (29). These workers showed that the reactions brought about by two or more organisms in association are very different from those produced by any in pure culture. The explanation of this phenomenon is as follows: One of the pair of bacteria must be capable of attacking the lactose to form acid while the other must be able to form gas from a hexose, such as glucose. Similar conclusions were arrived at by Leitch (30), Holman and Meekison (31), and Castellani (32).

VARIOUS DYE MEDIA

A tremendous amount of research work has been carried on in various parts of the country on the use of media containing various dyes with and without bile for a primary enrichment broth. This work has been reported on from time to time and the results are most

encouraging. As is well known, the purpose of the dyes is to inhibit the growth of organisms other than those belonging to the colon group, and which may give false presumptive tests in lactose broth tubes.

Churchman (33) (34) (35) showed that gentian violet is very toxic for the Gram-positive organisms, but has very little action on the Gram-negative bacteria, except in high concentrations. The spores of Gram-positive organisms such as *B. subtilis* and *B. anthracis* may be killed. The effect of the dye was better described as bacteriostatic rather than bactericidal. The same author (36) also showed that it is possible to mix a dye showing bacteriostatic action such as gentian violet with one exhibiting reverse bacteriostatic action such as acid fuchsin. In the former case only Gram-positive organisms are affected, whereas in the latter instance only the Gram-negative organisms are involved.

Hall and Ellefson (37) (38) recommended the use of gentian violet for the elimination of false presumptive tests in routine examinations. These authors found that the per cent of confirmed lactose broth tubes was much higher in the dye broth than in the medium containing no dye. Gentian violet has been used by a host of other investigators for the solution of individual problems. Similar conclusions were reached by Petroff (39), Bernstein and Loewe (40), Wagner and Monfort (41), Gay and Beckwith (42) Norton and Davis (43), Stearn (44), Burke and Skinner (45), and Wiesner (46).

Brilliant green with and without bile is used probably more than any other dye in bacteriological work. This dye possesses marked bacteriostatic and bactericidal properties for the Gram-positive aerobic bacteria and the anaerobic spore formers. Moreover, this dye is also somewhat toxic for the members of the coli-aerogenes group of organisms. Muer and Harris (47), Levine (48), Winslow and Dolloff (49), Howard and Thompson (50) and others have shown that brilliant green broth without bile is highly inhibitory and useless except to restrict the growth of the colon group.

Results are far superior if bile salts are used instead of whole bile, as it is almost impossible to prepare two lots of dehydrated bile of the same composition. Muer and Harris (47) and Hale (51) recommended the use of brilliant green bile broth as a positive test for *B. coli* without further confirmation. The former workers found that the growth of *B. welchii*, *B. sporogenes* and other anaerobes was restrained. The conclusion reached by Dunham, McCrady and

Jordan (52) Howard and Thompson (50) and others is that, although fewer positive presumptive tests are found with green bile than with lactose broth, the per cent of confirmed tubes is much higher. On the other hand, Ruchhoft (53) believed that green bile broth is too inhibitive to the *B. coli* group for direct planting into the medium.

CHEMICAL CONSTITUTION OF DYES

It is rather unfortunate that gentian violet was ever used because of its uncertain chemical composition. It is not a definite chemical compound but rather a mixture of dyes of a certain group (54). The various dyes in the mixture all belong to the pararosaniline series and it is practically impossible to obtain two brands or even two lots of the same composition. One of the ingredients of this dye is crystal violet for which a definite chemical formula can be given (hexamethyl pararosaniline) and this compound is to be preferred in bacteriological technic.

Browning (55) (56) (57), and his associates, have found that crystal violet is one of the most active bactericidal substances known. Complete inhibition of staphylococcus occurs with a concentration of 1:5,000,000 to 1:1,000,000. On the other hand the amount necessary to inhibit the organisms of the coli-aerogenes group is very much greater, i.e., about 1:500. The same writers have shown that brilliant green (tetra-ethyl di-amido tri-phenyl carbinol) produces similar results on the Gram-positive organisms, but, in addition, is about twenty times more toxic for *B. coli* than crystal violet.

From these results it would appear that crystal violet is to be preferred to brilliant green for the elimination of false presumptive tests because of its relatively non-toxic action on the coli-aerogenes group. Brilliant green has enjoyed widespread popularity chiefly because it was found superior to crystal violet for the isolation of *B. typhosus* from stools. In this instance the typhoid organisms are wanted and not the *B. coli*, whereas in water laboratories *B. coli* is the organism sought.

COMPARISON OF CRYSTAL VIOLET AND BRILLIANT GREEN

Experimental work which has been carried out in the State Laboratory, on a comparison of brilliant green and crystal violet, has given the following data:

Reciprocals of concentrations not hindering maximum growth

ORGANISM	CRYSTAL VIOLET	BRILLIANT GREEN
<i>B. coli</i>	150,000	100,000
<i>B. aerogenes</i>	70,000	60,000
<i>Staph. albus</i>	9,200,000	6,000,000
<i>Staph. aureus</i>	9,200,000	3,200,000
<i>B. subtilis</i>	7,200,000	1,600,000


These results show that crystal violet is far superior to brilliant green because of the greater margin of safety between the Gram-negative and the Gram-positive organisms. This work supports the contention of Browning that crystal violet possesses marked advantages over brilliant green where it is desired to recover *B. coli*. Further work is now being carried out and it is hoped to incorporate these results in the form of a new differential broth medium.

DIRECT PLATING MEDIA

Attempts are being made to develop agar media to be used for the direct enumeration of the colon organisms in water samples. Ayers and Rupp (58) used a preparation similar to Endo medium, but with a synthetic agar base, for the direct enumeration of organisms. Noble (59) employed a cyanide-citrate agar similar to the medium of Muller (60) (61). Direct plating of water samples possesses the advantage over preliminary enrichment in that it does away with the phenomenon of antibiosis which occurs quite frequently in certain water supplies. This is a point that cannot be overlooked. However, such work is still in the experimental stage and considerably more data are required before any conclusions can be drawn.

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PHOSPHATE IN BOILER WATER CONDITIONING¹

By R. E. HALL² AND ASSOCIATES³

I. PREVENTION OF SCALE FORMATION

Water treatment

At one time or another, practically all substances that form insoluble precipitates with calcium or magnesium have been suggested for use in water treatment. Thus in 1823 Samuel Parkes,⁴ in his "Chemical Essays," recommended barium chloride, potash, and soda; in 1838, Melville,⁵ and in 1841, Clark,⁶ patented the application of lime to water softening. Brooman⁷ in 1850 specified soluble salts of barium, strontium, and lead, oxalates, tartrates, sulphates, phosphates, pyrophosphates, borates, vegetable ashes, soap, caustic or carbonated potash, soda and ammonia, lime (quick or slaked), and any organic acid yielding insoluble salts of lime. The silicates, chromates, hydroxides, and aluminates⁸ have been recommended at different times. The zeolites,⁸ natural and artificial, have been given much attention.

In the application of these various chemicals to the treatment of water, and more especially feed water for boilers, there have been two distinct schools. One has devoted its attention mainly to the development of suitable equipment for softening water and for sepa-

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² Director, Hall Laboratories, Inc., Pittsburgh, Pa.

³ H. A. Jackson, E. W. Butzler, J. A. Robb, E. A. Hertzell, of Hall Laboratories; G. W. Smith, Hagan Corporation.

⁴ Parkes, Chemical Essays, 2nd Ed. (1823), page 355. Dingl. Polyt. J., 22, 114-134 (1826).

⁵ Melville, Brit. Pat. 7562, (1838).

⁶ Clark, Brit. Pat. 8875, (1841).

⁷ Brooman, Brit. Pat. 13,256 (1850).

⁸ An extensive bibliography is given in Bulletin 24, Mining and Metallurgical Investigations, Carnegie Institute of Technology, Pittsburgh, Pa., pp. 39-43.

rating the sludge thereby developed and has been generally content to use the most economical chemicals available. In the development of the zeolite process, research has been necessary on its special chemical, as well as on equipment. The criterion of this school has been the clarity and the degrees of residual hardness in the water leaving the softener.

The other school has fed the chemical to the feed water or boiler without special equipment other than the essential chemical tanks and pumps. In many instances, the simple chemicals used by the first school have been used. On the whole, however, the tendency has prevailed to mix a variety of ingredients into a boiler compound. The charlatan has flourished with his boiler compound, and in ignorance or indifference has imposed on an uninformed and too-trusting clientele. True, not all boiler compounds must be condemned as worthless; yet even Commander Lyon's Navy Boiler Compound⁹ is uneconomical to use, even though one purchases and mixes the ingredients for himself. The criterion in this school, where any existed, has been mainly the condition of the boiler when opened, or at times, the alkalinity or the hardness of the boiler water.

The criterion of the clarity or the degrees of residual hardness in a treated feed water takes no cognizance of the temperature of the boiler water (operating pressure) or of the accumulation of acidic radicals therein, and therefore omits consideration of the chemical equilibria which may develop at the evaporating surfaces. The criterion of the condition of the boiler when opened, or of the alkalinity or hardness of the boiler water also neglects this factor and does not provide adequate or timely corrections for aperiodic variations in the feed water.

Boiler water conditioning

As long as boilers were built in small sizes and operating pressures and ratings remained relatively low, these deficiencies in water treatment could be tolerated. Economical operation today, however, makes little allowance for boilers in stand-by condition, but demands rather that all boilers be maintained in continuous operation, and in condition to work at high rating in order to carry the load when any exigency arises. Thus, both for the elimination of one incidental cause for taking a boiler off the line and for the assurance of certainty

⁹ Lyon, J. Amer. Soc. Naval Engrs., 24, 867 (1912).

of operation at high rating, the operator must know continuously that the evaporating surfaces are free from scale, and must have systematic control for maintaining this condition.

In order to specify the essential exact control, the authors found it necessary to establish the general principles which dominate the mechanism of scale formation:¹⁰

1. When aqueous solutions, which contain substances whose solubilities increase with increase of temperature, are concentrated beyond their saturation value, these substances deposit as sludges at heating surfaces, but as adherent scale at cooling surfaces; if their solubilities decrease with increase of temperature, the reverse is the case.

2. The formation of adherent scale occurs *in situ*—that is to say, the main structural constituents of the scale are deposited from solution directly as scale, and not as solid individual particles which later agglomerate and thus form scale.

These two generalizations necessitate the conclusion that it is the primary function in treatment of water for use in boilers to control the characteristics of any solid phases which may separate at cooling or heating surfaces respectively. Treatment based upon this principle the authors have designated Boiler Water Conditioning.

Systematic control

The objective of systematic control is therefore the continuous maintenance in the boiler water at the evaporating surfaces of chemical equilibria such that any solid phases developed shall have a positive solubility—temperature coefficient and therefore form as non-adherent sludge. The choice of chemical for maintenance of control must be based on effectiveness in prevention of adherent scale formation, ability to conform to the recommendations of the A. S. M. E. Boiler Code regarding embrittlement,¹¹ and finally on economy.

(a) *Soda ash and its limitations.* As soda ash is a standard, low-priced chemical, its possibilities and limitations will be considered first. Its reaction with calcium salts, under boiler water conditions, results in the formation of calcite which is notably non-adherent,¹²

¹⁰ Hall and Merwin, Trans. Am. Inst. Chemical Engrs., 16, Part II, 98 (1924).

¹¹ Section VII, A. S. M. E. Boiler Construction Code (1927), American Society of Mechanical Engrs., 29 W. 39th St., New York, Paragraph CA 5, pp. 80-81.

¹² Kendall, Phil. Mag. (6), 23, 958-76, (1912), Hall, Ind. Eng. Chem., 17, 286, (1925).

and by decomposition, soda ash furnishes the hydroxide essential for combining with magnesium, aluminum, iron, manganese, etc.

Four and a half years ago, the authors determined the carbonate concentrations essential in the boiler water to control the equilibria at the evaporating surfaces, and developed a series of curves suitable for routine control in the boiler room.¹³ With definition of the essential carbonate concentrations, it immediately became apparent to them that it was hopeless to expect to control the equilibria at higher pressures by means of soda ash for the following reasons:

1. The concentration of dissolved carbonate, (CO_3), necessary in the boiler water becomes greater, the higher the operating pressure. Simultaneously the higher operating pressure (higher temperature) accelerates the decomposition of soda ash dissolved in the boiler water with the formation of caustic soda and carbon dioxide, the latter being evolved in the steam. Thus, while it might be possible to maintain the necessary carbonate in the boiler water, it becomes uneconomical because of the large quantities of soda ash required.

2. More important than economy, however, is the impossibility at higher pressures of maintaining in the boiler water the ratio of total alkalinity calculated as sodium carbonate to sodium sulphate recommended by the A. S. M. E. Boiler Code. Thus if the soda ash decomposes to the extent of 65 per cent, the limiting pressure at which this ratio can be maintained is 200 pounds. If the decomposition is 70 per cent, the limiting pressure is 182 pounds, and if 75 per cent, the limiting pressure is 163 pounds. As the decomposition of the sodium carbonate in general approximates the higher figures, the limiting pressure for its use lies not above 200 pounds and usually much lower.¹⁴

3. Conditions of high hydroxide alkalinity favor the accumulation of undesirable silicates in the boiler water, and, as shown in the second part of this paper, are inimical to good boiling.

(b) *Systematic control with phosphate.* In view of these facts, the authors were confronted with the necessity of choosing some chemical for water conditioning which while attaining the end of preventing adherent scale formation would also be stable at high operating

¹³ Hall, Fischer and Smith, *Iron and Steel Engineers*, 1, 312-27, (1924). Hall, *Ind. Eng. Chem.*, 17, 283 (1925), U. S. Patent No. 1, 613,701, January 11, 1927.

¹⁴ An excellent discussion of the difficulties at higher pressures is found in Publication No. 256-71, National Electric Light Association, pp. 4-5, (1926).

pressures, and permit control of the hydroxide alkalinity in the boiler water. When the choice of chemical had been made, it was necessary to determine thereon those constants, knowledge of which was essential to control the chemical equilibria at the evaporating surfaces.

Consideration of organic materials was discarded because of their increasing readiness of decomposition with increasing operating pressure, the difficulties of testing for their concentration in the boiler water, and their too-great cost. Oxalates are included in this group.

Of the possible inorganic substances, the silicates were impossible because the calcium- and magnesium-silicate scales are the most difficult of all to deal with.¹⁵ The chromates were discarded because of the negative solubility temperature coefficient of calcium chromate and its considerable solubility.¹³ The aluminates could not be given consideration because of the solubility of calcium aluminate,¹⁶ and because of the formation by alumino-silicates at points of limited circulation of the boiler water of undesirable soft deposits which are tenaciously resistant to removal by washing. While the fluorides have been recommended by Doremus,¹⁷ and are stable at the higher pressures, their close relation chemically to the chlorides, which are so definitely specific in corrosion,¹⁸ was sufficient to exclude them from consideration.

Thus the decision was reached to concentrate attention on the use of phosphate.¹⁹ From the standpoint of stability, the phosphates meet all requirements. Qualitative tests showed that tricalcic phosphate is more insoluble than calcium carbonate. While phosphate had been used to some extent in water treatment, no data could be found relative to any exact use based on the boiler water. The use of the Navy Boiler Compound would result in the presence of caustic soda and sodium carbonate in the boiler water and the absence of phosphate therein unless excessively large quantities of the compound were used. Commander Lyon based his tests on alkalinity alone.

¹⁵ Hall and Associates, Bull. 24, Mining and Metallurgical Investigations, Carnegie Inst. of Tech., Pittsburgh, Pa. pp. 23-5 (1927).

¹⁶ Heyrovsky, Chem. News, 125, 198-200 (1922). Later confirming references are Kühl and Thüring, Zement, 13, 109,246 (1924).

¹⁷ Doremus, U. S. Patent No. 404,180, May 28, 1889, J. Am. Chem. Soc., 12, 303, (1890); 15, 610 (1893).

¹⁸ Evans. The Corrosion of Metals. E. Arnold & Co., (1924).

¹⁹ Reference (13), p. 317.

Two steps were immediately taken to obtain exact data on the use of phosphate. (1) Opportunity came early in 1924 to recommend its use on boilers operating at 325-350 pounds pressure. Recommendations were made that the concentrations of phosphate (PO_4) be maintained in the boiler water in accordance with the curves developed for carbonate. It was recognized that this was an upper limit, but data were lacking for a lower limit. (2) An investigation was begun in the laboratory whose aim was to determine the solubility of tricalcic phosphate at boiler water temperatures.

The results obtained on the boilers were eminently satisfactory, and have been fully described in the technical press.²⁰ The results of the laboratory investigation showed tricalcic phosphate to have an extremely slight solubility.²¹ On the basis of the solubility data, the essential concentrations of phosphate to maintain in the boiler water have been determined,²² and expressed in the form of curves for boiler room use.²³

The condition of the evaporating surfaces resulting from the continuous maintenance in the boiler water of the essential concentration of dissolved phosphate leaves nothing to be desired, whatever the operating pressure, and whether the raw-water make-up is 100 per cent or the small amount incident to condenser leakage. With the maintenance of these conditions, any need for the turbinizing of tubes disappears. It is essential, however, that the hydroxide alkalinity (OH) in the boiler water be maintained at not much less than 25 p.p.m. and better at 50 p.p.m. or more, to insure the most economic use of the phosphate chemical and the optimum of cleanliness on the surfaces. Our experience in the use of phosphate has received confirmation in the work of Anderson,²⁴ Sprague,²⁰ and that of LeTellier and Sunder;²⁵ Yoder²⁶ offers the only dissenting opinion.

Economic application of phosphate control

The authors would never use soda ash as conditioning chemical, other than to provide requisite alkalinity when required, were its

²⁰ Power, 60,930, (1924); Publication No. 25-68, National Electric Light Association, pp. 8-10 (1925). Sprague, Power, 65, 321-2, (1927).

²¹ Reference (15), p. 72.

²² Hall, Mech. Eng., 48, 319-21 (1926).

²³ Hall, U. S. Pat. No. 1,613,656, January 11, 1927.

²⁴ Anderson, Engineering, January 13, 1928, pp. 55-58.

²⁵ LeTellier and Sunder, Chemie et Industrie, pp. 241-3, September, 1926.

²⁶ Yoder, Power Plant Eng., 30, 1316-8 (1926).

Cochrane Bulletin No. 670, (1926) pp. 119-20.

cost not so much less than that of phosphate. Because of the greater cost of phosphate, consideration must be given to its economical application.

In general, up to 150 pounds operating pressure, the maintenance of the carbonate-sulphate ratios essential to control the chemical equilibria at the evaporating surfaces can be accomplished successfully. Whether this shall be done by direct treatment, with disposal of sludge by blowdown, or through the medium of a lime-soda or zeolite softener, must depend upon the muddiness or clarity of the raw-water, its content of temporary and permanent hardness, the percentage of raw make-up, whether or not there are economizers, the type of boiler, the rating at which it is operated, etc.

At pressures much in excess of 150 pounds, especially if the per cent of rating and raw make-up is high, or if much silica is present in the raw water, final conditioning of the boiler water by the maintenance of the essential phosphate-sulphate ratios is by far most satisfactory. If the amount of raw make-up water is small, or if the hardness is slight, direct treatment of the water without softening equipment is entirely satisfactory. In case of greater hardness in the water, however, preliminary treatment by a lime-soda or zeolite softener is advisable, to remove as much as possible of the calcium and magnesium by the cheaper chemicals, and thus economize on the amount of phosphate used.²⁷ Whether the softener should be lime-soda or zeolite, must not be decided on the basis of the residual hardness of the effluent water, but on the type of hardness in the raw water and the conditions necessary for the protection from corrosion and caustic embrittlement of the surfaces following the softener. Owing to the fact that the solubility of tricalcic phosphate is much less than that of calcite, or other form of calcium carbonate there is no advantage in a simultaneous treatment of water with soda ash and phosphate, as the equilibrium in the boiler water will be on the carbonate-sulphate ratio, unless sufficient phosphate is used to render the soda ash unnecessary save for the purpose of furnishing hydroxide alkalinity.

Conclusion

The total solids in the boiler water represent a summation of the constituents present in the dilute raw water. Thus the authors find maintenance at the evaporating surfaces of the essential equilibria based on operating pressure and sulphate concentration simple

²⁷ Hall, Tran. Am. Soc. Mech. Engrs., 47, 803, (1925); see also reference (22).

and exact, when controlled by tests on the boiler water, whether treatment is by direct addition of chemical, or by means of a softener. There is the further advantage in this control that all discrepancies in the operation of the softener are smoothed out in the maintenance of the equilibria. When higher operating pressures make phosphate requisite for the final conditioning, it may be used directly, or following the softener, as economy dictates; but success therewith depends upon its maintenance in the boiler water as free dissolved substance, together with a slight hydroxide alkalinity, and its control must be based on boiler-water tests. With maintenance in the boiler water carefully controlled, turbinizing of tubes becomes obsolete.

II. RELATION TO SMOOTH BOILING AND WET STEAM

Before making definite application to conditioning by means of phosphate it is the authors' purpose to discuss some of the factors influential for better or worse in changing the boiling characteristics of water. In part they agree, in part disagree, with those published reports which have come to their attention.²⁸ No formulation of theory will be attempted.

The modern boiler must be kept continuously in operation over long periods, and the processes of scale formation and corrosion must be definitely inhibited. For the certain attainment of these ends, the boiler water must be devoid, as far as possible, of scale-forming elements in solution (mainly calcium and magnesium) and must be definitely alkaline (should contain as a minimum approximately 50 to 100 p.p.m. of hydroxide radical.) In any remedial measures directed to the control of foaming conditions, these fundamental characteristics of the boiler water must not be tampered with.

Observations have been confined to ebullition in closed vessels with outlets of limited size for the escape of steam, thus assuring contact at the steam-liberating surface between water and a gaseous phase containing only very small and chance quantities of components other than the steam. The experimental work has been done at normal boiling temperature, and at ratings based on volume-separa-

²⁸ Koyl, R. R. *Gaz.*, 32, 663, (1900); 34, 423, (1902). French, *Ind. Eng. Chem.*, 15, 1239, (1923). Foulk, *Ind. Eng. Chem.*, 16, 1121, (1924). J. Am. Water Works Association, 17, 160 (1927). Geol. Survey of Ohio, (H) Bull. 29, pp. 114-22. Hall, Fischer and Smith, *Iron and Steel Engr.*, 1, 312, (1924). Millard and Matson, *Ind. Eng. Chem.*, 17, 685, (1925). Joseph and Hancock, *J. Soc. Chem. Ind.*, 46, 315 T. 1927. Ewell, *Power*, 67, 370, (1928).

tion of steam per unit area of the liberating surface and comparable to actual operating conditions.

The term *foaming*, as used in this discussion will signify the conditions developed in the ebullition of water or aqueous solutions which destroy the clear demarcation between the continuous gaseous and the liquid phase by a sharply defined liquid surface devoid of bubbles which persist for a perceptible period, and substitute therefor an interface composed of the surfaces of bubbles which persist without rupturing for a shorter or longer period. The characteristics of this layer of bubbles between the continuous gaseous phase and the true body of liquid phase are dependent upon the size of the bubbles; the resistance of their walls to rupture, which in turn vary with the character and concentration of the soluble and insoluble substances in the liquid phase; and also upon the rate of their generation at the heated surfaces of the steam generator and the type of circulation therein. The type of bubbles developed at the heated surfaces, and rising through the liquid phase under these conditions is characteristic, as the bubbles are smaller than in the ebullition of the pure liquid phase, do not readily coalesce into larger bubbles, and thus fill the liquid phase with a vast number of individual small bubbles. When this condition exists, the water level as indicated by the gauge glass of a steam generator is not truly indicative of the quantity of liquid in the generator. These conditions typify foaming, and it is these conditions which accentuate the presence of unevaporated water in the steam leaving the steam nozzle.

Boiling characteristics in the absence of suspended matter

Neutral solutions. When pure water is boiled, steam disengages at the heated surfaces in the form of large bubbles that rise rapidly and turbulently through any supernatant water, and at the interface of continuous gas phase and water phase, burst practically instantaneously, and become an integral part of the gas phase. Ebullition with these characteristics the authors define as *smooth boiling*. At the time of rupture of the steam bubble, the forces involved are usually sufficient to rend partly into spray the thin shell of water which encloses the steam bubble just prior to its disruption, and this spray exists as heterogeneously distributed discrete particles in the gaseous phase, so long as the force of gravity acting thereon is unable to effect their return to the surface of the liquid. The duration of their existence in the gaseous phase is conditional upon their size and

density, and the density and the upward component of velocity of the gaseous phase. The existence of these discrete particles is inherent in ebullition even under optimum conditions, and their removal from the gaseous phase is best effected by mechanical means such as a steam separator.

A sudden increase of load on the boiler accelerates the rate of bubble formation, but the steam-liberating surface remains devoid of persistent bubbles.

The characteristics of boiling change with the addition to the pure water of soluble materials, as sodium or other sulphate, chloride, or nitrate, or their mixture with sugars, hexoses, the soluble polyhydric alcohols as glycerin or mannite, the alkali metal salts of tannic, gallic, acetic, tartaric and many other organic acids, and divers other organic substances. Thus, dissolution in the water of a few hundred parts per million of the inorganic sodium salts produces little effect on boiling conditions; but as the concentration is increased, the size of the steam bubbles rising through the liquid phase decreases, they do not readily coalesce in their passage to the steam-liberating surface, and their bursting is no longer instantaneous. As a result, layers of unburst bubbles exist at the steam-liberating surface. As their disruption occupies appreciable time, the number of layers present at any moment for any arbitrarily chosen concentration of dissolved solids is a function of the amount of steam which must be furnished by the boiler; i.e., a function of the rating.

The higher the concentration of dissolved salts, the smaller the size of the bubbles, and the greater the delay in their disruption. Thus under these conditions, a thicker layer of unburst bubbles exists in the steam-liberating surface for the maintenance of equilibrium between rate of bubble formation and disruption for steady load. When any sudden steam-demand is thrown on the boiler, the layer is greatly increased in thickness, owing to the sudden disparity in rate of bubble formation and disruption, and the boiler foams violently.

The effect of different inorganic solutes appears to be additive.

Effect of acidity ($\text{pH} \approx 5$ approx.). The concentration of dissolved material at which any change from the characteristics of pure-water boiling becomes noticeable is very much higher.

Effect of alkalinity ($\text{pH} \approx 9$ approx.). When substances such as sodium hydroxide, carbonate, borate, or phosphate are dissolved in pure water to the extent of a few hundred parts per million, the

characteristics of boiling are not changed markedly, though more so than by neutral substances. The concentration requisite for foaming conditions is least for sodium hydroxide; but the tolerance of the water for any of the substances mentioned is less than for the neutral substances.

When the pH value of the water is maintained equal to or greater than 9, approximately, and the small concentration of alkali solute therein is augmented by the dissolution of neutral substances, foaming conditions are induced at considerably lesser concentrations than in neutral solutions.

Effect of soaps. Very specific are the effects engendered by the addition of a soap to water devoid of solute other than the alkali necessary to maintain $\text{pH} \geq 9$. A very few parts per million is sufficient to alter noticeably the characteristics of steam-bubble formation. The soap may be the saponification product of animal or vegetable fats and oils, or be derived from resins, gums, coal tar, colophony, etc.

The addition of a soap to an alkaline water containing a few hundred parts per million of dissolved neutral substance, produces a far more marked effect; and as the concentration of neutral substance is increased, a few parts per million of the soap may produce practically intolerable boiling characteristics.

Boiling characteristics in the presence of suspended material

In any consideration of the effects of suspended material on the boiling characteristics of water for steam generation, the range of concentrations to investigate is much more limited than in the case of dissolved substances. This follows for two reasons, namely: (1) As an extreme upper limit the concentration of suspended material should not exceed one or two thousand parts per million, and is preferably limited to values very much less. (2) The construction of many boilers provides sufficiently for settling of the suspended solids in chosen positions, so that these concentrations will not be exceeded with reasonable blow down.

In experimentation of this nature, it is difficult to establish criteria by which exact comparisons can be made. In this discussion, the observations refer to suspended matter which is wetted by the water. In general, it may be said, that augmentation of such suspended material in a water affects the boiling characteristics in manner in much the same way as the dissolved neutral substances,

but in degree, somewhat more. In general, also, freshly precipitated iron, aluminum or magnesium hydroxide, or calcium phosphate—all characterized by extreme fineness of division—has more detrimental effect on boiling conditions than a crystalline precipitate such as calcium carbonate or sulphate.

The precipitation of a few hundred parts per million of suspended matter in pure water changes the characteristics of boiling very little. In an alkaline water, however, and as the concentration of dissolved neutral substances is augmented, development of foaming characteristics occurs at lesser concentrations of the latter than in clear solution. The addition of extremely small quantities (often not more than 5 p.p.m.) of a soap to such a mixture exhibiting moderate or even slight foaming tendencies, can readily induce extreme foaming conditions.

A wide range of tests, both on synthetic mixtures and actual boiler waters, both with and without organic contamination as by soaps, verifies the conclusion that filtration of suspended solids to perfect clarity may modify to some degree, but does not at all nullify, foaming characteristics. Also, in general, an environment permissible in boiler waters which induces ready flocculation of any finely divided suspended material when the water is quiescent, is of negligible influence in abating foaming characteristics.

Some water-soluble exceptions to the general rules

In considering these exceptions, it is unnecessary to specify whether suspended solids are present or not, as the conclusions apply in either case. In order to arrive at general conclusions, however, it is essential that the soaps be excluded.

An interesting demonstration of a water-soluble exception may be made as follows: To water, alkaline to the extent of 100 or more parts per million of hydroxide, is added sodium chloride until the boiling is characteristic of foaming. Next, some 30 or more parts per million of calcium as the chloride, or other convenient soluble salt is added. The introduction of the calcium betters boiling conditions very markedly, though not to the extent of the perfect boiling of pure water. Finally, upon the addition of a few parts per million (usually from 10 to 20 is sufficient) of the sodium salt of tannic acid, foaming entirely disappears.

Barium or strontium may be substituted for calcium in this experiment. Sodium sulphate, or a mixture thereof with sodium chloride

or other soluble sodium salts that do not remove the calcium, may be used in place of the sodium chloride. Cutch, quebracho extract, or other sources of the tannates, or the sulphite-cellulose extracts,²⁹ may be substituted for sodium tannate. A like effect is obtained with the sodium salts of gallic or pyrogallic acids, tartaric acid, citric acid, though the latter two do not give so pronounced results. Obviously barium and strontium cannot be used in sulphate waters.

The removal of the calcium from the smoothly boiling water as by sodium carbonate, thus disrupting the trinity of alkaline earth metal, hydroxide, and tannate, causes the return of foaming conditions; addition of calcium again terminates it. Perhaps the action of the alkaline earth metal is that of a scavenger in maintaining the steam-liberating surface free of traces of saponifiable material.

There seems to be little leeway in choice either of metals or organic substances which are thus effective. Apart from the alkali and the alkaline earth metals, there are few soluble metallic hydroxides. Thallium is an exception in this sense, but follows the alkali hydroxides in its effect on foaming. Certain metallic hydroxides dissolve in sufficiently alkaline water, as aluminum or zinc hydroxide, but in so doing form complex metal-containing negative radicals, and leave the solution devoid of heavy-metal ions. Thus, the alkaline earth metals seem to be the only possibilities, and of these calcium is scale-forming, and sulphate removes the other two.

Likewise, there is a very limited choice in the organic members of the trinity. Thus, among the aliphatic substances, the hydroxy acids, tartaric and citric are in some degree effective; lactic or succinic acid is not. Other hydroxy bodies, as the glycols, glycerol, mannitol, dextrose, sucrose, etc. have no effect on foaming conditions or else increase them by increasing the concentration of dissolved solids. In the aromatic series, the try-hydroxy phenols, as pyragallol, gallic acid and the tannins have been mentioned. Monohydric phenol, phthalate, salicylate and cinnamate are ineffective.

The extensive use of tannates in boiler compounds has always excited interest, and many an explanation has been offered as to why their use is beneficial. In 51 United States patents on boiler compounds examined, issued in the period 1866-1927, 26 contain the tannates in one form or other. In the light of the foregoing discussion the authors are of the opinion that the usual undertreatment

²⁹ Technologic Paper No. 339, Bureau of Standards, gives analyses and an excellent discussion of this type of material.

of the boiler water with these compounds results in the requisite calcium, tannate and hydroxide to give relatively smooth boiling conditions, that this is the function of the tannates, even though unrecognized, that resulted in their extensive use, and that the issue of controlling boiling has been generally confused with that of scale prevention.

The facts presented also shed light on the reason for the oft-repeated statement that the presence of soda ash in a boiler water is the primary cause for foaming. As is often the case, correct observation has been followed by incorrect interpretation of the cause. The removal by the soda ash of the calcium ion terminates the beneficial effects of the latter on foaming. Thus the cause of the foaming is not primarily the addition of soda ash to the boiler water, but the removal thereby of the calcium; and likewise, a similar effect is exerted by any material which removes the calcium. By whatever method complete treatment is given, therefore, control of boiling conditions is more difficult than when calcium ion is present in the boiler water.

The high rating and the high pressure boiler can tolerate only the slightest concentration of calcium in the boiler water, because their surfaces must be maintained free from formation of silicate or sulphate-of-calcium scale at all times. Thus, the very exact and complete water conditioning essential for them precludes any assistance from the substances heretofore mentioned as water soluble exceptions to the general rules of boiling, and necessitates careful attention to the problem of extending as far as possible the limit of tolerance of their boiler waters to dissolved and suspended solids.

The use of phosphate, either alone or following a softener, and while preventing all scale formation at all pressures, permits easy control of the alkalinity of the boiler water almost impossible, or not easy to obtain by either lime-soda or zeolite unassisted, and careful control of alkalinity can go a long way in control of foaming. In addition, the design of boilers, freedom of the boiler water from saponifiable materials, proper blowdown, installation of effective purifiers or separators at or beyond the steam nozzle, are all factors to be taken into consideration in controlling the condition of the boiler water. Also, in the installation of new boilers, full consideration should be given to the design in its relation to the time it allots and the conditions it imposes for the disruption of the steam bubbles.

Some water-insoluble exceptions to the general rules

There seems to be little hope of finding specific anti-foaming combinations for fully treated waters among the water-soluble substances. A brief discussion of a few water-insoluble substances will be given. The absence of soaps in the boiler water is assumed.

A hydrocarbon, such as paraffin or ceresin, seems effective to a slight measure in inhibiting foaming. If the hydrocarbon be treated with bromine, it becomes more effective, and retains this effectiveness after boiling with caustic soda. The authors ascribe this result to the greater polarity of the brominated molecule, and probably to the changes in the surface energies concerned.

In general, the vegetable and animal fats and oils, before their saponification occurs, possess definite anti-foaming characteristics. Castor oil falls in this class, as do cottonseed, olive, cocoanut, and a host of others. Once saponified, however, they aggravate foaming conditions.

Likewise, the waxes possess anti-foaming characteristics. Beeswax, Carnauba wax, spermaceti, lanolin, are notable examples. Saponification of these bodies results in part in the formation of sodium salts of organic acids which foster foaming, and in part in the formation of alcohols, usually monohydric, which are characterized by double bonds and hence, polarized molecules, and which therefore should be anti-foaming in character.

The results of experiments are definite. Myricyl, ceryl, cetyl, dodecyl, cholesterol, and many other of the alcohols are extremely effective in repressing foaming conditions. Since they do not saponify in an alkaline water, their accumulation therein does not aggravate foaming conditions, as happens with the fats, oils, and waxes.

The asphalts represent a rich source of double bond molecules, which do not saponify to any large extent. Experiments with them, and with various of their components separated by extraction processes, have shown them to be excellently effective in repressing foaming.

Coal tars possess anti-foaming characteristics, but readily lose these properties in hot alkaline water.

Thus an extensive choice of water-insoluble materials with anti-foaming characteristics is available, and of these a large number do not present the difficulty of ready saponification. Why, then, cannot the problems of foaming be easily met by their use?

Naturally, the saponifiable substances cannot be used in an alkaline water except with recourse to heavy blowdown, and this, in itself, greatly lessens any foaming tendency. Likewise, if the alkalinity of the water is made nil, there is little use for an anti-foaming reagent, since both the pH value and the greater concentration of calcium usual under this condition favor smooth boiling.

Two factors interfere with any consistency of results from the substances which do not saponify. One is that at the temperature of boiler operation, the organic molecules may not be stable over long periods, and especially in alkaline water at the higher operating pressures. The hydroxyl radicals and the double bonds are points at which the molecule may be attacked. A second factor is the ready absorption of the large organic molecule by any finely divided precipitates in the water, thus removing their effectiveness. The constant replacement that may thus be necessary brings the cost to uneconomical proportions.

Effect of an insoluble gas

All of the substances thus far discussed, either water-soluble or insoluble, are of little or no avail in the presence of saponified materials. The only method that the authors have found effective for coping with foaming caused by both dissolved and suspended solids, as well as by saponified materials, is the introduction into the boiler water of an insoluble gas, as air, nitrogen, etc. in sufficient quantity, which mingles with the steam, and probably through inequalities of partial pressures renders unstable the films surrounding the steam bubbles.

Conclusion

It seems advisable, therefore, to recognize fully the general laws which govern the boiling of water in enclosed vessels, and the difficulties which are experienced in attempts to circumvent these laws by chemical means. It thus becomes the duty of the chemist to prescribe and obtain careful control of the alkalinity in the boiler water, systematic blowdown, and cleanliness from all saponified and saponifiable materials; and to insist upon the mechanical aids of careful control of water levels, proper baffling of the steam drum, purifiers or separators at or beyond the steam nozzle, and at such points as are necessary to insure a clean condensate return. The compounded cylinder oils, that have any opportunity of getting back

to the boiler water, should be selected with full recognition of the boiling conditions they may foment. When new boilers are to be installed, they should be chosen with regard to the water to be used and their steam-liberating facilities, as well as the other usual factors

DISCUSSION

H. C. DINGER:³⁰ In the article by R. E. Hall on "Phosphate in Boiler Water Conditioning," the author refers several times to Captain Lyon's Navy Boiler Compound or its use as a boiler water conditioner. This reference appears to be to a paper published by Captain Lyon in 1912. Various changes in the content and the application of Navy Boiler Compound have been made since then. In order that there be no misunderstanding as to the amount of Navy Boiler Compound used in boiler water treatment, attention should be invited to the fact that while the condition of the boiler when opened and the alkalinity of the boiler water are still used as the basis on which subsequent treatments are made, the alkalinity recommended in Navy Regulations for the past 14 years is 0.2 to 0.5 per cent normal alkaline strength instead of the 3 per cent as recommended in Captain Lyon's article, referred to by the author. The present formula is as follows:

Navy Standard Boiler Compound

	per cent
Soda ash- Na_2CO_3	76
Trisodium phosphate, $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$	10
Tannin.....	2
Starch.....	1
Water.....	11

It will be noted that a considerable percentage of trisodium phosphate is used. The main reason for its use has been to deter priming. Its presence, however, also would tend to maintain the proper carbonate-sulphate ratio. Marine boilers using distilled water as make up have no need to worry about caustic embrittlement, even if alkalinity is carried fairly high. The use of Navy Boiler Compound has given entirely successful results on Naval boilers of 300 pounds pressure operating at very high rates. It is true that the Navy Boiler Compound method of boiler water conditioning does not

³⁰ Captain, U. S. Naval Experiment Station, Annapolis, Md.

take into consideration the chemical equilibria which might take place at the evaporating surfaces, nevertheless, the treatment has proved both practical and successful in keeping naval boilers free of corrosion and scale under the conditions existing aboard ship, namely, practically 100 per cent distilled make-up water and working pressures ranging from 200 to 300 pounds per square inch.

In recent years the working pressures of marine boilers have been getting higher until 350 pounds per square inch has been reached. Under these conditions, the soda ash of Navy Boiler Compound has its limitations, and this is fully realized by the Experiment Station. The use of trisodium phosphate in conjunction with recently discovered colloids appears desirable for pressures above 300 pounds. For this reason a series of practical boiler tests are being conducted in an endeavor to develop a boiler water treatment to meet the more exacting conditions of high rates and high temperatures, and at the same time have something of practical application aboard ship by the ordinary personnel of the engineering force.

The systematic control of the chemical equilibria existing at the evaporating surfaces such that the solid phases developed will form as non-adherent scale, as advocated by the author, is believed to be an effective and economical means of preventing adherent scale formation, but at the present time is impractical aboard ship and in small boiler plants because the chemical apparatus and the solubility data necessary for carrying the treatment are not available to those responsible for the care of the boilers. It is also believed that the article by R. E. Hall would be of much greater practical value if the solubility data contained in some of the references were included in the article. More definite data as to the temperature and pressure at which soda ash fails to render satisfactory service would also be of special interest. From naval experience there are quite definite indications that it will render effective service up to 300 pounds pressure. As far as prevention of scale is concerned, it appears that some of the colloids such as sodium alginate mixtures and some of the specially processed sodium aluminates when used in proper proportion with some of the commonly used alkalis and subjected to proper chemical control, have very definite advantages.

J. D. YODER³¹: Dr. Hall's reference to the writer's disagreement with him as to the effectiveness of phosphate treatment compared

³¹ Cochrane Corporation, Philadelphia, Pa.

with carbonate is based upon his discussions on this subject in "Power Plant Engineering" and the Cochrane Bulletin No. 670 in 1926. These articles were based upon the results obtained from a Cochrane Hot Process Softener at one of the large plants of a public utilities corporation with water particularly low in mineral solids and, therefore, favorable to the use of phosphate treatment. After a fair trial the operating engineer discontinued the use of phosphate treatment and returned to the use of soda ash and sodium sulphate in proportions to maintain a proper relation of sulphates to carbonates to prevent embrittlement. The boiler pressure at this plant was 275 pounds per square inch.

This test was conducted before Professors Parr and Straub reported on the effectiveness of tri-sodium-phosphate for preventing embrittlement. Their first public indorsement of phosphate for this purpose was given in the University of Illinois Bulletin No. 177 published June, 1928. This publication states that tri-sodium-phosphate has by laboratory tests been proven effective in preventing embrittlement regardless of the sodium carbonate to sodium sulphate relationship. This places a very considerably different aspect on the use of tri-sodium-phosphate because in the test to which the writer previously referred it was the expectation and desire to hold the sodium carbonate to an amount sufficiently low that a relationship of alkalinity in terms of sodium carbonate to sodium sulphate would not exceed 1 to 3 as called for by the A. S. M. E. Boiler Code for 275 pounds working pressure.

As referred to in Dr. Hall's paper the phosphate reacts with calcium and magnesium in preference to the carbonate radical to form calcium or magnesium phosphate and sodium carbonate. The sodium carbonate concentrates in the boiler to an amount equivalent to the calcium and magnesium carbonates originally present. The sodium carbonate thus formed, during the test reported, was more than one-third of the sodium sulphate present even though the tri-sodium-phosphate fed was not sufficiently high to protect the boilers from a troublesome deposit. The tri-sodium-phosphate, therefore, proved incapable of protecting the boilers from scale and at the same time maintaining an alkalinity of sodium carbonate low enough to guard against embrittlement.

The customer after a fair trial decided upon a return to the use of sodium carbonate and sodium sulphate which he found effective for his requirements.

However, since having the assurance of Professors Parr and Straub that the continual presence of a small amount of tri-sodium-phosphate in the boiler will prevent embrittlement even though the sodium carbonate may be high with respect to sodium sulphate a considerable advantage is given to the use of tri-sodium-phosphate for the high pressure boilers. The writer, therefore, desires to state in support of Dr. Hall's advocacy of phosphate for high pressure boilers that it is now the policy of the Cochrane Corporation to advocate that the hot process lime and soda treatment should be supplemented with tri-sodium-phosphate for boiler pressures of 350 pounds per square inch and higher, operating under a license of the Hall patent.

Two hot process water softeners have been sold on this basis, one for 650 pounds and the other 450 pounds pressure. By this method of treatment it is not intended that the alkalinity in the boilers must be maintained so that its sodium carbonate equivalent will be less than one-third of the sodium sulphate. It may be very considerably higher. Illustrating this it is generally found that with the hot process treatment it is not necessary to add more than $1\frac{1}{2}$ grains per gallon (26 parts per million) excess sodium carbonate in which event the hardness of the softened water will be approximately $1\frac{1}{2}$ grains per gallon (26 parts per million) in terms of calcium carbonate.

If the treatment of such a water is supplemented with tri-sodium-phosphate, sufficient of the latter must be fed to react with the $1\frac{1}{2}$ grains per gallon residual hardness plus a small excess so that an appreciable amount of tri-sodium-phosphate will always be maintained in the boiler. The sodium carbonate alkalinity of the softened water will, therefore, be approximately 3 grains per gallon which includes the excess sodium carbonate fed in the softener plus the sodium carbonate formed by the reaction of the tri-sodium-phosphate with the calcium and magnesium carbonates. By depending upon the availability of the tri-sodium-phosphate for prevention of embrittlement, it is, therefore, possible to have the presence of a relatively large excess of sodium carbonate in addition to the phosphate which should make a very desirable water for high pressure boilers.

This illustration does not take into consideration the use of the disodium phosphate or the acid phosphate. If the latter were used obviously the phosphate radical might be increased without increasing the sodium carbonate alkalinity, thus taking advantage of the phosphate radical for preventing scale without the consequent

increase in sodium carbonate. Dr. Hall has referred to this possibility in some of his writings although to date I have had no opportunity to observe the effect of this in practice.

It does not seem that a consideration of all of the facts would justify the conclusion that Dr. Hall reaches in the first of the two general principles that he enumerates in explanation of the mechanism of scale formation. The principle he sets down is that calcium sulphate scale forms only because it becomes increasingly insoluble at higher temperatures and that calcium carbonate forms a sludge and no scale because its solubility increases slightly at the higher temperatures. In substantiation of this principle Dr. Hall has referred to the fact that a calcium carbonate scale frequently forms on boiler feed piping because the surface of this pipe is slightly cooler than the water on account of radiation. This explanation is at variance with the facts that a high carbonate water also forms scale on the surfaces of economizers and feed water heaters to the same extent or even greater than it forms on the feed water piping. In the latter case the surface of the piping is cooler than the water but with economizers and feed water heaters the surfaces are hotter than the water.

Likewise if a boiler feed water is not treated calcium sulphate scale forms on stay bolts and boiler headers as well as on the tubes. The boiler tubes give up heat to the water and the boiler headers radiate heat from the water.

The principle laid down by Dr. Hall does not, therefore, seem to be substantiated by all the related facts.

It seems more logical to explain the formation of scale in feed water heaters, economizers and boilers as the crystallization of these solids from the super-saturated solutions resulting either from heating alone as in feed water heaters and economizers or by heating and evaporation as in the boilers. It is well known that super-saturated solutions are encouraged to give up their solids by the frictional resistance of water passing over surfaces and when the crystals are once formed on the surfaces they tend to grow and form a scale.

On the other hand if a water is treated with chemicals either within the boiler or externally the cause for deposition of the solids is not the slow super-saturation of the solution but deposition results from chemical reaction, the precipitating re-agent being present in considerable excess. Under such conditions the solids precipitated either in a laboratory beaker, a boiler or any other commercial

vessel are brought down in the form of sludge or floating particles. This also applies to calcium sulphate when it is precipitated by adding a considerable excess of sodium sulphate to calcium chloride when these substances are present in amounts appreciably beyond the solubility of calcium sulphate. Under these conditions the precipitation of calcium sulphate is very similar to the usual precipitation of calcium carbonate in a boiler when the water is treated with sodium carbonate or tri-sodium-phosphate.

LABORATORY TESTS IN WATER WORKS OPERATION¹

By A. E. BERRY²

In Ontario, to-day over 240 water works systems are in operation. Of this number 50 are operating filtration plants, while over 110 are treating their supplies by chlorination. Such treatment processes, all subject to breakdowns or irregularities, must be carefully controlled by laboratory tests if assurance is to be had of the results obtained. Considerably over 75 per cent of all water used for domestic purposes receives treatment of this kind. Other provinces may show an even higher figure.

LABORATORY FACILITIES

The accessibility of laboratory facilities tends to control the extent to which these tests are generally applied. Such services may be divided into two classes including (1) the plant laboratory, and (2) the provincial or municipal laboratory. The Ontario Department of Health maintains 8 laboratories together with an experimental station. These are located at convenient points to serve the whole province, namely at Toronto, London, Peterborough, Kingston, Ottawa, North Bay, Sault Ste. Marie and Fort William. Train service permits water shipments in a few hours, which in most cases overcomes the necessity of icing the samples. The services of these laboratories are available to every water works plant in the province. Last year over 20,000 water samples were analyzed by the various laboratories, but unfortunately most of these came from a limited number of supplies, while others sent none whatever or very few at most. Fifty per cent of the Ontario supplies had less than 50 analyses each, last year and 40 per cent had none whatever. Generally it is the municipality without expert supervision which fails to take advantage of the service offered. The extent to which laboratory tests are made indicates in a measure the degree of supervision maintained. Some of the larger municipalities also maintain their own

¹ Presented before the Canadian Section meeting, March 7, 1928.

² Director, Division of Sanitary Engineering, Provincial Department of Health, Toronto, Ontario, Can.

general bacteriological laboratories, and have the analyses made there, under the local board of health.

Independent bacteriological laboratories operated at water works plants are comparatively few in Ontario, and with the service offered by the province it is very doubtful if such laboratories would be of material advantage, except in the larger plants with a technically trained personnel. This is even more apt to be true when it is considered that the technique in bacteriological analyses offers greater chance of error than in other examinations. There does, however, appear to be a very distinct field for the plant laboratory in other activities. It is encouraging to note the prominence given to these in the newer plants.

LABORATORY SERVICE REQUIRED

Obviously the amount of laboratory service which should be provided for any water works system will depend on a number of factors. Deep well supplies, which are not subject to serious contamination require little laboratory control. Surface supplies, on the contrary, with varying degrees of contamination and treatment, must require numerous checks. Waters subject periodically to pollution by sewage, trade wastes or similar material, require very careful laboratory supervision.

SAFETY OF THE SUPPLY

The first requirement of any water works operator is to ensure the safety of the supply. His control must be such that, at all times, he can adequately protect the consumer against water-borne disease outbreaks. He can, without serious results, permit tastes or turbidity to appear so long as the water is safe. The decisions of the courts also indicate that the municipality or water works owner must be held responsible for the safety of the water delivered. The operator can only make sure of this safety by sufficient laboratory tests. The more tests employed the greater should be his assurance of the quality.

PHYSICAL QUALITY

Next to the safety the physical condition of the water must claim the attention of the operator. A water supply must not only be safe at all times, but it must also be in such condition that it will be used willingly by the consumers. Taste, color, or turbidity are always

objectionable. To remove these satisfactorily requires, in many cases, very careful control of the reactions involved. Laboratory analyses are practically indispensable for this work.

SAVINGS

The expenditure for a plant laboratory may frequently be offset by the saving accomplished in the treatment. Reports are not uncommon in which a reduction in chemicals as high as 50 per cent, amounting to several thousands of dollars per year, has been accomplished. Such a saving can only be expected where there is a thorough laboratory study of the supply. From such figures and from a knowledge of conditions at treatment works in general there is every reason to believe that a plant laboratory is of the utmost necessity in the control of operating costs.

RESEARCH IN PLANT OPERATION

Water supplies vary a great deal in their requirements and in methods of treatment. What is applicable to one may not be to another, but each offers an individual problem, from which something can be learned. Water works men must study their own local conditions, and develop methods which will meet their needs. The different examinations made should be studied in an endeavour to determine what is most valuable. Such a study must be sufficiently comprehensive to include varying conditions of the raw supply.

Coördinated research at various water treatment plants will accomplish much for the science. Complex waters are continually introducing new problems. Progress cannot well be left in the hands of a few workers. An accumulation of data from many plants is particularly desirable in furthering research. The research facilities of the Department of Health are always available for assistance of municipalities in problems of this nature.

ROUTINE TESTS

It is not easy to select the routine tests and their desired frequency for each plant. The greater the number of tests, the more assistance they will be to the operator. This will of course be governed by the facilities available. For the average plant the following tests are suggested as routine.

1. *Bacteriological analyses.* As bacteriological analyses serve to check the safety of the supply they are of paramount importance. The Department of Health suggests that water samples be sent in once or twice per week. Where the supply requires more careful treatment daily samples may be necessary. Since a few bacteriological samples over a long period seldom present a true picture of conditions, samples should be forwarded at least weekly.

2. *Ortho-tolidine tests for chlorination control.* This test, now used in practically all plants in the province where chlorination is practiced, is a very simple one and can be carried out hourly or as required. It permits the operator to adjust his dosage satisfactorily. Every test should be recorded so that the exact residual at any one time may be in the records. The Department of Health has made a practice of distributing ortho-tolidine to the various water works plants in the province, as well as the color standards necessary for making the test.

3. *Color.* Records of the color content of the water before and after treatment furnish valuable information in connection with plant operation. The reduction of color to a reasonable figure is a necessary part of the treatment.

4. *Turbidity.* Turbidity records of surface supplies are desirable and necessary in the operation of the plant.

5. *Temperature.* Temperature statistics for the various seasons of the year furnish interesting and valuable data.

6. *Hydrogen-ion.* Hydrogen-ion tests are useful in the control of the treatment process. Suitable outfits are now on the market for plant use and tests may be made very easily. It is well to remember in using these scales that the values do not represent simple arithmetical changes.

In addition to the above, ammonia determinations are used. These require however much equipment for the small laboratory. Dissolved oxygen tests may also be made and the equipment for this is not elaborate.

Every water works system should have a complete analysis of its supply. It will prove most valuable for a number of purposes.

LABORATORY PERSONNEL AND TRAINING

The value to be derived from any water works laboratory is dependent largely on those responsible for its operation. No laboratory can function properly without adequately trained personnel. In the earlier works there appeared to be little inclination to employ technically trained men or to provide money for the maintenance of such work. To-day an adequate supply of trained men familiar with the technique and value of laboratory procedure is available and it is increasingly common to find operators with this qualification. For the smaller plants, it is obvious that some arrangement must be made whereby the operators will be enabled to secure the necessary training. This may be accomplished partly by the study of literature and by attending conventions.

The training of water works personnel has been accomplished in several places by water works schools or short courses. In these, men have an opportunity to come together annually, or more often, and to brush up on laboratory methods and other operating technique, or to learn what other plants are doing to solve their difficulties. Such a course would differ from the usual convention in that it would follow the lines of a school training in which the student would start at the beginning and learn the specific reasons or underlying principles of the various methods. It would permit the beginner and those who have forgotten some of these details to acquire a valuable training in a convenient way. The period for holding such a school would necessarily be short to encourage operators to attend. Attendance at these courses is always a problem and the question arises as to whether it should be made compulsory for the municipality or water works company to send their officials the same as is required in other lines of municipal activity. It is, of course, somewhat difficult for many operators to be away for any lengthy period. The plant must be operated and their absence might necessitate calling in untrained men for a time. Suitable arrangements might be made whereby a certain part of the staff would be permitted to attend at one time and the balance at a subsequent school. It is also questionable whether such courses should be held at one central point or whether they should be arranged at convenient plants throughout the province. Undoubtedly the practical working of a treatment plant could be best demonstrated at the plant itself. By arranging the courses at a number of different points it might be possible for the operators from the adjoining municipalities to attend for a definite period each day, which would take them away from their regular work as little as possible. The department of health in conjunction with other agencies should conduct these courses. Suggestion has been made that certificates of standing be awarded to these operators whose training has met with the approval of the Department. Such a suggestion has some attractive features, and it should prove a very valuable recommendation to the operators themselves when they desire to secure new positions.

PLANT RECORDS

Any discussion of laboratory tests would not be complete without reference to the keeping of plant records. In the smaller plants unfortunately little, if any, attention is paid to this phase of the

operation. The benefit of past experience in the operation of the plant is thus lost with every change of personnel. The operator can only supply from his memory what he thinks was done under certain conditions. Cost data and other valuable information are lost not only to the municipality itself but to others interested in these problems. In many plants, the equipment is such that it is almost impossible to keep records. Sufficient attention has not been paid to the installation of meters and similar measuring and recording devices. The initial expenditures in many instances have been so severely cut that these necessary parts of the plant were omitted.

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POOLS AND POOLS¹

BY ARTHUR M. CRANE²

The increasing number of public swimming pools and wading pools, owned and operated by the municipality, make this subject of interest to waterworks men. Today municipalities are competing with amusement parks and providing pools holding one, two and three million gallons, resulting in a considerable draft on the municipal supply unless re-filtration be employed.

The majority of wading pools do not use re-filtration but are supplied with a constant flow of new water. This must mean something even in a city as large as Dallas, Texas. There they have about 20 wading pools, most of them about 30 feet by 50 feet in area.

The water demand, therefore, concerns the waterworks man, even if he is not called upon for advice in the planning of the pool. As a matter of fact, waterworks men in general should be strong advocates of pools, so as to keep down the contamination of their water supply.

If we search the Scriptures, we are appalled when we read of the "great multitude of impotent folk, of blind, halt, withered" who bathed in the Pool of Bethesda "by the Sheep Gate" in the Holy City. But in those days *B. coli* and other modern bugs were unknown and people did not realize the danger of spreading their diseases, although in Jerusalem the lepers were supposed to be segregated outside the city walls.

Bethesda and Siloam were not swimming pools, but were storage or equalizing reservoirs in the waterworks system of old Jerusalem, with its twenty-five miles of conduit from the mis-called "Pools of Solomon"—partially restored by General Allenby and his British forces during the World War.

In the current issue of a water works journal a recent photograph shows a bunch of kids bathing in the reservoir from which the old city of Jericho takes its water supply. From this it would seem that some

¹ Presented before the Missouri Valley Section meeting, October 5, 1928.

² International Filter Company, Chicago, Ill.

things are not a good deal different now in Palestine than they were when Christ visited the Pool of Bethesda.

At this point here let us digress long enough to pay our respects to one of the old-time consulting engineers. It was in the year 896 B.C. that the Prophet Elisha was sojourning in Jericho (as recorded in the nineteenth verse of the second chapter of the second book of Kings):

And the men of the city said unto Elisha, Behold, I pray thee, the situation of this city is pleasant, as my lord seeth: but the water is naught, and the ground barren.

And he said, Bring me a new cruse, and put salt therein. And they brought it to him.

And he went forth unto the spring of the waters, and cast the salt in there, and said, Thus saith the Lord, I have healed these waters; there shall not be from thence any more death or barren land.

Flavius Josephus (A.D. 37-100) adds:

To these prayers Elisha joined proper operations of his hands, after a skillful manner, and changed the fountain. . . . (Wars of the Jews—Book IV, Chap. VII, Sect. 3.)

Students see in these accounts reference to early methods of water purification. Perhaps some day a Palestine Exploration Fund will excavate direct evidence that the Prophet Elisha was actually the consulting engineer for the City of Jericho.

But the ancients had nothing on us in this matter; for even today we bathe in our waterworks reservoirs or in the streams which supply them. True it is that several states prohibit bathing in water which is to be used for a public supply, but these are few and far between.

A few months ago, the writer, acting for the American Association for Promoting Hygiene and Public Baths, addressed an inquiry on this subject to the health authorities of our 53 states, territories, and island possessions and the result is given in the 1928 *Journal* of the Association under the title: "Promoting Pools by Prohibiting Bathing in Waters used for Domestic Purposes." This shows that actual state prohibition of bathing in domestic water supplies exists in California, Connecticut, Massachusetts and New York.

Kansas and Maine and perhaps other states have the authority, but have not enacted regulation.

In Montana and probably other states, there is no specific enactment; but it is prohibited under general laws governing sanitation of surface waters.

In Illinois, Louisiana, Maine, New Mexico and doubtless elsewhere, it may be, and is, prohibited by city ordinance or water company charter.

In Texas, a recent court decision restrained the use of a swimming pool in the Navasota River because it emptied into and polluted the lake of water impounded for domestic use by the city of Groesbeck.

But, on March 23, 1927, New Jersey set a horrible example by repealing a restrictive regulation of the State Department of Health and enacting a statute specifically granting the right to bathe in any of the fresh waters of the State. This statute reads:

It shall be lawful to bathe or swim in any of the fresh waters of this State, provided, that in so doing no trespassing be committed.

Of course, this is all a part of the broad subject of stream pollution; but, while seeking to prevent contamination by sewage and industrial wastes, it will be well to remember that excretions from one typhoid patient might start a first class epidemic.

If we cannot bathe in the river or the reservoir, and we should not, then we must have pools. And as the cry is not only for more pools, but for bigger and better pools, the whole subject is of vital interest to the city engineer and water superintendent.

The earliest pools in this country were merely enclosures in the rivers. Then scows were used. In 1915 New York added a refinement by making its floating baths watertight, so as to prevent seepage, and supplied them with water from the city mains.

Indoor public baths came into use in Philadelphia in the eighties. In these, the pool area was not roofed. Consequently they could not be used in cold weather.

According to the late Dr. Simon Baruch, who is credited with being the founder of the public bath movement in the United States, in 1900 there were only 67 public pools in this country.

In 1913, the writer located only 540 pools in the whole United States. Of these 250 reported their dimensions. They ranged from 10 feet by 20 feet to 65 feet by 140 feet.

The ancients bathed chiefly as a part of their religious ritual or to cleanse the body or be healed of some disease. The early public baths in this country were patronized largely by persons without bathing facilities at home and this is as true of the baths equipped with pools as of those having only tubs or showers. But today the Saturday night bath is taken in a tub or shower and the pool is

reserved for recreation. The change is epitomized in the slogan of a prominent bathing suit manufacturer who advertises: "The suit that changed bathing to swimming."

The popularity of the pool has grown to such an extent that the first class ocean liner is incomplete without one. At this moment the United States Shipping Board is installing them on the former German ships—"Monticello" and "Mount Vernon."

In the United States Army 59 establishments have pools, the largest entirely artificial one being 55 feet by 169 feet at Camp Harry J. Jones, Arizona.

Last year the American City "Municipal Index" discovered or uncovered 3,212 pools public and private, indoor and outdoor, in the cities of 5000 population and over. The 1928 edition of the last mentioned publication gives data on 223 outdoor municipal pools in 103 cities, ranging in cost from \$200 to \$135,000.

The increasing size of the present day pool and the state requirements as to water supply make the subject of particular interest to the waterworks man.

While fifteen years ago a 65 feet by 140 feet pool was considered a large one, today the pools in our parks are rapidly approaching those of ancient Rome.

Some of the famous structures of old time were mighty small compared with those of today. Solomon's temple was only 42 feet by 125 feet in plan and 63 feet in height.

But there was nothing skimpy about the engineering works of the Romans. Sextus Julius Frontinus, who was Superintendent of Water works in Rome under Nero, left us a complete account of their system. They had 8 aqueducts varying from 11 to 62 miles in length, conveying upward of 200,000,000 gallons of potable water to the population of $1\frac{1}{2}$ to 2 millions, or between 160 to 200 gallons per capita per day. These aqueducts had settling basins in which the water was treated before it was delivered to the distribution reservoirs within the city.

Their pools were of the same magnitude. In the third century A.D., Rome had 952 small bathing places and 12 large ones. The smallest, that of Titus, was 341 feet by 390 feet and the largest, that of Diocletian, 1300 feet by 1333 feet, with accommodations for 3000 people.

Today cities are vying with amusement parks in building artificial pools which would take the entire output of a small town waterworks.

For example, the new pool of the Westchester County Park Commission at Rye, New York, is to hold approximately 516,000 gallons as against its next door neighbor, Magner's Pool (a commercial enterprise) which holds 502,000 gallons.

The pool which is about to be built for Elizabeth, N. J., which will hold 400,000 gallons, is nearly as large as the Magner Pool; and the municipal pool at Esterville, Iowa, holding 375,000 gallons, is in this class.

East Cleveland's Municipal Pool, holding 500,000 gallons, is almost in the class of the nearby Idora Amusement Park Pool at Youngstown, Ohio, which holds 740,000 gallons.

There are several other municipal pools now being planned which will run as large or larger than Chester Amusement Park at Cincinnati—which has a capacity of nearly $1\frac{1}{2}$ million gallons.

In 1915 the American Association for Promoting Hygiene and Public Baths adopted suggested standards for swimming pools, including one reading as follows:

Unless there is a constantly inflowing stream of absolutely pure, clear, colorless, fresh water, this condition should be approximated by filtration, re-filtration and disinfection.

At that time only one state, Louisiana, had any regulations and they did not go into details of the water supply. Now 27 states have definite and arbitrary regulations and 21 states require that plans must be submitted, or a permit secured, or the pool registered with, or reports made to, the state board or department of health.

There has been wide divergence in the state regulations, but they are becoming more uniform since the promulgation of the Report of the Joint Committee on Bathing Places of the American Public Health Association and the Conference of State Sanitary Engineers.

Thirteen states now specify a definite degree of bacterial purity. Of late the tendency has been to stipulate the results rather than specify the means thereto. New Mexico is a good example of this. Formerly they required 800 to 2000 gallons per bather. But several states still require a definite quantity. California wants 1000 gallons of new water for each bather in "fill and draw" pools, to which they, and other authorities, are opposed.

Kansas requires, and South Dakota recommends, 1000 gallons for each 15 persons using the pool during any period of time. This is equal to $66\frac{2}{3}$ gallons per bather.

Virginia cut down its former recommendation of 500 to 800 gallons, to 100 gallons, per bather, and is now being guided by the Joint Committee's report.

The "suggestions" of Georgia name 600 gallons per bather as the desirable quantity.

For "fill and draw" pools, Arkansas, Florida, Mississippi, Tennessee, Washington and Wyoming are satisfied with the "weekly bathing load of 20" (equal to 50 gallons per bather) suggested by the Joint Committee, but "prefer" a constant flow of new water equal to "400 gallons per person per day considered on an average daily attendance."

Oklahoma absolutely requires 400 gallons per bather both for "fill and draw" pools and those where re-filtration is employed.

Of course, if the demands either as to quantity or degree of purity of water had to be met by a constant flow of water from the city mains, there would be fewer pools. But re-filtration makes it possible to use the initial supply (with a little daily "make-up") for weeks or months without emptying the pool.

The writer's survey in 1913 disclosed only 54 out of 272 pools employing re-filtration. Today re-filtration is universal.

There may be a few city fathers who cannot see why they should spend money for filters for the park pool just after they have paid for a city filtration plant; but they are getting fewer every day.

When re-filtration was first practiced about twenty years ago, it was chiefly in indoor pools and to conserve the water and heat. Today, health is the primary reason for re-filtration, although without it the cost of operation would prohibit pools in many places. Re-filtration not only conserves water and heat, but keeps down the contamination of the water by the bathers.

In 1915 Manheimer cited 19 authorities who had reported venereal, ocular, aural or intestinal diseases contracted from swimming in polluted water.

In 1920, Hinman tabulated the diseases as follows:

1. Intestinal infections, such as typhoid fever, dysentery, etc.
2. Infections of the respiratory system, such as grippe, colds, sore throat and sinus infections.
3. Eye and ear infections, such as conjunctivitis, rhinitis, and ethmoiditis.
4. Gonorrheal infections.
5. Skin infections.

Reports of the diseases contracted by children in wading pools and tests showing highly contaminated water, have impelled the American Association for Promoting Hygiene and Public Baths to undertake an investigation of this subject. So far we have received reports from 77 pools. These show that the average area is as large as the swimming pools reported in our survey of fifteen years ago, although the average maximum depth is necessarily lower, this being 20 inches.

In the majority of these wading pools there is a constant in-flow while the pool is in use.

Out of 44 of these pools, 21 or nearly 50 per cent refill daily, 2—twice a day, 3—four times a week, 6—three times a week, 6—twice a week and 7—once a week.

It remains to be seen whether or not the American Public Health Association and State Sanitary Engineers will take cognizance of the situation. A number of the members of both organizations have expressed themselves in agreement with our feeling that authorities should ordain the same standard of purity for wading pools as for other "Bathing Places."

It would be quite unnecessary to go into structural details which should be left to the architect or engineer. It would be impracticable and would prevent an increase in wading pools to require a pre-cleansing shower; but the lack of a "scrub" and the fact that many of the youngsters wear dirty clothes which are immersed in the pool, makes imperative a constant flow of pure water.

DISCUSSION OF THE MANUAL OF WATER WORKS PRACTICE¹

I. WATER PURIFICATION

BY ERNEST BOYCE²

When one attempts to discuss the contents of a book and especially a reference work such as the Manual, it is necessary to visualize the purpose that the author or authors had in planning the subject matter. This is both difficult and delicate. The following discussion is undertaken with the knowledge that it is far easier to read and criticize than to create the original. This book represents the thought and labor of many water works men and its compilation was no small task. We would not attempt to review critically any portion of the Manual were it not for the request that comes from the Association for such discussion. No apology is needed for the Manual as first published,—it deserves a place in the reference file of every water works man. At the same time, there are few books that cannot be improved upon, and when the time comes for a revision of the Manual, it will help those charged with this duty to have the results of constructive discussion.

In briefly reviewing or outlining those chapters of the Manual that deal with water treatment, it will be our purpose to indicate the scope of the subject matter presented and to comment with regard to its arrangement with particular reference to the relative space given the subjects discussed.

The Manual is divided into six general sections as follows:

1. Collection of water
2. Quality of water
3. Treatment of water
4. Distribution of water
5. Financing and management
6. Fire protection

¹ Presented before the Missouri Valley Section meeting, October 4, 1928.

² Director, Division of Water and Sewage, State Department of Health, University of Kansas, Lawrence, Kans.

The part assigned us is that having to do with the third section,—Treatment of Water. This is covered by seven chapters with a total of 132 pages or approximately one-fifth of the book.

Chapter 6 is the first one in this section and devotes 20 pages to three topics:

	pages
1. Self purification of streams.....	12
2. Advantages of outlets at different levels for deep reservoirs....	1
3. Current practice for algacides.....	7

The section dealing with self purification seems very well written. The reader has the natural conditions of stream life explained briefly and then the effect first of organic pollution and later the effect of trade wastes. With this picture of the unbalanced biological condition existing in the stream, the following paragraphs discuss how the natural factors act to restore, in so far as possible, the original stability of the stream. First, there is a discussion of the longevity of pathogenic bacteria and a listing of factors that influence their vitality in this changed environment.

The factor of dilution is next, then sedimentation including natural coagulating effects. The effects of light and aeration are briefly discussed. The paragraph on the digestion of organic matter is very important and while well written it perhaps does not occupy the space that might be devoted to this part of the subject.

The page dealing with outlets at different levels for deep reservoirs is really a part of the discussion on algae, the use of these outlets at varying depths being for the purpose of securing water at those levels where it is most free from algae. The use of copper sulphate as an algacide is given rather full discussion with a rather limited discussion of the use of chlorine and hydrate alkalinity for this purpose. One is disappointed in not finding any guide as to the possible toxic effects from the excessive use of copper sulphate.

Before leaving Chapter 6, we might mention that it seems that the subject matter of this chapter is somewhat unrelated and that all three topics should appear at the heading of the chapter.

Chapter 7, in 15 pages, deals with the single subject Chlorination. The chapter is well written, giving a historical introduction followed by a discussion of chemical-biological effects. The manufacture of chlorine and its compounds and their uses as applied to water disinfection are described briefly, concluding with paragraphs discussing

the results that can be obtained with chlorine, both as a bactericide and also as a means of controlling algae odors. The point of chlorine application is mentioned including pre-chlorination. The dosage is discussed with reference being made to super-chlorination and de-chlorination, a subject also mentioned under algae control.

Unfortunately for the reader, other methods of water disinfection are not included in this chapter, nor do they appear in the chapter immediately following. Chapter 7 on chlorination ends on page 188 and Chapter 11 on ultra-violet-ray treatment and ozonization is found on page 264. Since all of these methods deal principally with water disinfection, it would seem that they might be combined in one chapter under the heading of Water Disinfection, and that the historical treatment of this subject be made to include all methods.

It would also seem logical that the various steps in water treatment should be used as a guide for chapter arrangement. If this were done, disinfection, being one of the last steps, would be discussed following the chapter on coagulation and filtration, but ahead of a discussion of special processes not in general use.

Chapter 8 devotes 57 pages to the subject of filtration, including preliminary treatment, under the following general headings:

	<i>pages</i>
1. Aeration.....	5
2. Natural subsidence.....	5
3. Coagulation.....	9
4. Rapid sand filtration.....	17
5. Slow sand filtration.....	14
6. Double filtration.....	5
7. Covers for reservoirs for filtered and ground waters.....	2

This chapter occupies only slightly more than 9 per cent of the pages, or less than half of that portion of the book dealing with water treatment. This makes it necessary to treat the subject rather less fully than might seem desirable. For example, the history of filtration is of perhaps more general interest to water works men than the history of water disinfection. A historical review, such as was given on pages 476-481 of Transactions of A. S. C. E., Vol. 85, by Professor Geo. C. Whipple, would be of general interest. Because of the condensed nature of this most important chapter, it is disappointing not to find a bibliography at its end. The omission of bibliographies at the end of all chapters in this particular section is regrettable, the

one exception being the most excellent one following the discussion of the self purification of streams.

The arrangement of the subject matter in this chapter seems quite logical. The various treatment processes are taken up in the same order that one would expect to find them were he to follow the raw water through the plant.

Aeration is first discussed. Its use is explained as a means of improving the quality of water, not so much from chemical or bacteriological standards as from the less easily measured, but very important, standpoint of odor and taste elimination. This part of water treatment has possibly been crowded to one side in our desire to supply safe water and to measure the degree of safety by the laboratory processes now in use. The removal of odors and tastes produced by algae and the growth or disintegration of other microscopic organisms is given as the principal use of aeration, while its use in the removal of objectionable odors and tastes due to various industrial wastes, as well as for increasing the oxygen and reducing the CO_2 content are listed as a less frequent use. Since there are methods other than aeration for the control of odors and tastes and since this is a problem that requires more attention than has been given to it in the past, we might suggest that possibly it warrants treatment in a separate chapter dealing with the removal of dissolved gases, odors and tastes.

The second topic in Chapter 8 is Natural Subsidence. The settling of water without the use of a coagulant is discussed only in connection with the plain settling tanks which are used ahead of the chemical treatment to remove the heavier particles that will settle in a reasonable length of time without the use of coagulating chemicals.

The difficulty experienced in cleaning the mud from the basins is mentioned. Something might be said with regard to the importance of basin arrangement that permits the taking of any basin out of service without disturbing the operation of the plant. The use of mechanical devices for the removal of the settled mud is cited as being provided for in a large western plant. We note that this western plant referred to is not on the coast, but in Kansas City.

The third topic is coagulation. The chemicals used are discussed but without reference to the effect that these chemicals may have on the finished water or how the process of partial softening can be combined with coagulation. The various types of chemical feed devices are briefly listed and the popular preference for the use of dry feed

machines indicated. The different types of mixing flumes and mechanical mixing are listed. A description of the round spiral flow mixing tank as installed in the new Kansas City, Missouri, plant might be included in a revision.

The use of a reaction chamber following a short and rapid mixing and ahead of the settling tanks is not discussed as separate from the mixing tank. A reaction tank of this type seems important in some of the smaller plants, at least. The channels through which the water passes should be large enough so that the floc formation is not broken up, yet small enough to give a velocity that prevents sedimentation. Some plants have been built in Kansas so designed as to permit a varying detention period in the reaction tank, recognizing that the floc formation is slower in cold weather than under certain other conditions. Either by using it all or by passing a part of the channel forming the reaction tank, the water can be delivered to the settling basins properly coagulated. Slow eddy currents are desirable in sweeping out turbidity in coagulated water.

The construction of a second mixing and reaction tank at the outlet of the settling tank has also seemed desirable in some plants, in order that a satisfactory floc may be maintained on the filters. This is particularly important in the small intermittently operated plant.

The subject of coagulation is further discussed with regard to the factors that modify the efficiency of the process, including, (1), proper details of the application and mixing of the required chemicals; (2), the design of the settling basin including quiescence, detention and water displacement or the effectiveness of baffling devices to prevent short-circuiting; and, (3), the arrangement of inlet and outlet details. The efficiency of coagulation for turbidity and bacterial removal is treated in separate paragraphs followed by a brief review of the theory of coagulation.

Rapid sand filtration is described under the following paragraph heads:

- Descriptive features

- Essential details

- Materials of construction

- Underdrain system

- Sand depths and sizes

- Wash water troughs

- Size and number of units

- Valves and operating tables

- Arrangements for washing, including rate of washing, duration of wash, amount of wash water and air wash.

Mechanical agitators are mentioned as obsolete.

Appurtenances are listed including brief descriptions of rate controllers, filter rate of flow and loss of head gauges, and sampling devices. The desirability of some device for the accurate measuring of the turbidity of the effluent from each filter while in operation might be mentioned.

Operation is discussed, including rates of filtration, filter washing, maintenance, laboratory control and records.

The subject is closed by a discussion on the performance of rapid sand filters, giving a list of controlling factors and a review of the theory of filtering principles.

The fourteen pages devoted to slow sand filters will be passed over as being of little interest to this group. We are apt to view the relative importance of these two methods of filtration as they are adapted to the locality in which we are interested and from this standpoint it would seem that the treatment of the subject of slow sand filters is more in detail than might be warranted and that more space should have been given to the discussion of rapid sand filters.

The use of pre-filters to supplant coagulation in the preparing of badly polluted waters for either slow or rapid sand filters is reviewed, giving both American and European experiences. The use of pre-filters for the removal of normal carbonates in municipal softening plants to protect the final filters from sand incrustation is not mentioned. Several installations have been made in this section for this purpose.

Chapter 8 closes with an important discussion showing the importance of covering filtered and ground water storage reservoirs. The four reasons given are:

1. To keep out light and thus prevent green algae growth,
2. To keep out dust, air-blown spores and seeds,
3. To protect against human tampering,
4. To prevent the growth of plant moss in the distribution system.

Chapter 9 devotes 5 pages to the discussion of iron and manganese removal. Aeration by various methods is described as the first and most important step. The need for the removal of CO_2 is mentioned but more emphasis might be given to the fundamental change that must be accomplished,—that of changing the iron from its ferrous state to the more completely oxidized ferric state, in order to make it insoluble and its removal possible.

The use of coarse contact beds and plain sedimentation after aeration is mentioned, the latter as being limited in its application.

The use of sand filters, both as contact beds and as a finishing process, is made the subject of one paragraph with the use of chemicals mentioned in the last paragraph.

The chapter is interesting, but could be made of more help to a designing engineer in solving a problem of iron removal.

More emphasis we believe should be given to the treatment needed after iron oxidation and CO_2 removal by aeration. From observations in this section, it would seem very important to provide not only adequate facilities for lime application but also alum or other coagulant, and in most instances filtration after sedimentation. Softening processes can be combined in the same plants to good advantage.

Chapter 10 devotes 13 pages to various water softening processes. Lime-soda ash softening is first discussed, the subject being introduced by a discussion of the chemical reactions involved. The reader is quite properly referred to Standard Methods for methods of analysis.

The expression of results and the method of calculation is indicated.

Limiting factors are discussed, giving those that affect softening reactions as follows:

Time and temperature

Methods of agitation

Addition of alum compounds

Sludge return

Over-treatment, split treatment and carbon dioxide for the removal of normal carbonates.

Costs of lime-soda ash softening are given and methods of calculation, but unfortunately these costs are not extended to include zeolite softening discussed in the next chapter.

In view of the possibilities for the increased use of zeolite, including combining its use with lime to give a maximum removal of dissolved minerals and a minimum increase of sodium salts, the use of zeolite might warrant a somewhat more extended discussion.

Chapter 11 devotes three pages to the disinfection of water by the use of the ultra violet ray and by oxonization. Earlier in this paper, we suggested that it might be desirable to bring all disinfection methods together into one chapter.

Chapter 12, the last of those dealing with water treatment, gives a rather full discussion of the use of iodide in public water as a goiter preventive. The 18 pages are instructive and interesting. Some question might be raised, however, regarding the relative importance of this subject to the water works man. While there is little question as to the importance of an adequate supply of iodide in the food or drink of the human being and especially the growing child, there is some question among medical men as to the advisability of any general mass treatment. A treatment that might be given with great benefit to a group of school children might be harmful to some adults. The economy of treating 100 per cent of public water in order to have it present in the $\frac{1}{4}$ of 1 per cent, or less, used for drinking might be questioned. We believe that the water works man should be informed on this subject and perhaps know the iodine content of his water supply, but at best only a small portion of the total number of public water supplies are so designed as to make this medication possible. In view of this, if it is necessary to save space in the Manual, we believe that the treatment of this subject could be made more brief, without detracting from the usefulness of the Manual to most water works men.

In closing this paper and opening the subject for discussion, we hope that our comments will be received as constructive. The work of compiling into one volume all the many things that a water works man should know cannot be done. All that can be done is to group the discussion of problems of general interest into one book,—a shelf of books would be a better measure of the library needed to meet the needs of all. Fortunately, many good books are available and to these the Manual could well be added.

II. WATER SOFTENING

By F. M. VEATCH¹

In discussing Chapter 10 of the Manual of Water Works Practice, the first thing that occurs to me is that, of the $12\frac{1}{2}$ pages of descriptive matter given on this subject, 11 pages are concerned with the lime-soda process and the zeolite process is very sketchily outlined on a page and a half.

It is true that this manual is intended to reflect municipal water practice and that zeolite has not yet been used extensively in that

¹ Consulting Engineer, Kansas City, Mo.

field. However, it is a fact that, from a standpoint of chemical cost, zeolite treatment offers the most economical method of removing "permanent" or, if you please, "non-carbonate" hardness from water, and will, it seems certain, be used as a part at least of many future softening plants. The possible saving by the use of zeolite over soda ash for this purpose in one instance amounted to approximately \$10.00 per million gallons, or approximately one-half of the total cost of the zeolite treatment. On the other hand, a saving of approximately \$1.00 per million gallons is possible by the use of lime instead of zeolite for the treatment of temporary hardness in the above case. The most economical softening plant should include both processes.

The entire zeolite story should be told in as much detail as has been afforded the lime-soda treatment, and the limitations of this process should be made clear.

For instance, there are few, if any, surface water supplies in the middle west that are suitable for zeolite treatment without preliminary clarification, and many of our ground water supplies carry iron in sufficient quantities to prevent the proper action of a zeolite bed. It is an open question, whether or not zeolite treatment can be considered as a complete treatment for municipal supplies in any case, and this point deserves further treatment in the Manual.

It should be made clear that zeolite treatment does not remove salts from water, but simply replaces calcium and magnesium or "hardness" salts with sodium salts which are not "hard." Since this is true, no actual reduction in concentration of dissolved solids can take place and, in the case of many of our hard well water, there certainly is a question whether or not the treated water is better than the un-treated. This, of course, holds true for hard waters in which non-carbonate hardness predominates and in view of the fact that it is not generally understood that some waters are not susceptible to any softening treatment whatever, it seems to me that a paragraph to bring out this point would not be out of the way.

There seems to be a general impression that water is softened in a "water softener;" in other words, that it is a machine rather than a process.

On page 253, it is stated that 10.7 pounds of lime per million gallons of water were used to reduce the hardness one part per million, and on page 261 it is stated that the cost of lime for removing one part per million of non-carbonate hardness, from one million gallons of water, is 3.1 cents based on the use of 90 per cent lime at \$12.00 per ton, or

0.6 cent per pound. These two statements show a discrepancy of approximately 3 cents or 5 pounds, depending on which way one figures. Both figures are probably right and the discrepancy is due to differences in plant efficiency and to the amount of magnesium or turbidity encountered in the treatment. However, these discrepancies are not explained and the two figures do not check.

III. WATER SOFTENING

By SELMA GOTTLIEB⁴

It is no doubt exceedingly presumptuous for one inexperienced in plant practice to attempt a critical review of this chapter on water softening by such an authority as Mr. C. P. Hoover, but the difficulties connected with presenting the complex chemical phenomena of water softening in a brief space and in a simple manner demand the coöperation of all chemists in an effort to secure clarity and simplicity without sacrificing accuracy and comprehensiveness.

The usefulness of this chapter is of course seriously limited by the difficulty of discussing in 12 pages as important and complicated a subject as water softening. Since similar criticisms are likewise made of other chapters by workers especially interested in various other phases of water work, the question necessarily becomes one of expanding the book, perhaps beyond the compass of one volume. Besides the space required for the methods in use when this manual was compiled, a new edition will also need to provide for discussions of various important recent advances in water softening theory and practice.

A detailed consideration of the chapter leads to such suggestions as the following: Is the amount of lime usually used in water softening sufficient to insure killing intestinal organisms, as stated by Mr. Hoover in his preliminary arguments for softened water? Since few plants attempt to carry their treatment as far as does the Columbus plant, where the amount of lime added is probably enough to exert considerable bactericidal effect, this statement might give some operators a false sense of security with regard to the sanitary quality of very incompletely softened water.

In considering the causes of hardness in water, it would be just as

⁴Chemist, Division of Water and Sewage, State Department of Health, Lawrence, Kans.

clear, and more accurate, to call calcium bicarbonate and magnesium bicarbonate the products of the action of water containing carbon dioxide on limestone and magnesite, rather than to give the bicarbonates the names of the original minerals.

On page 252, in the second line of the fourth paragraph, and again on page 261, in the first line of the fourth paragraph, the term non-carbonate hardness is erroneously used for carbonate hardness.

To provide a more useful reference for the plant operator, additional space is particularly needed for discussing the chemistry of water softening and the calculation of the amounts of lime and soda ash to be added. The factors given for these calculations would be of greater applicability if the factor for converting CaO to Ca(OH)_2 were also included.

The accuracy and advisability of the term "negative non-carbonate hardness" may be seriously questioned. It deals with excess alkalinity, or carbonates and hydroxides, and yet is stated in terms of non-carbonates, a confusing and roundabout method. It is surely clearer to say that water which has been over-treated contains excess alkalinity as sodium carbonate, sodium hydroxide or calcium hydroxide, as the case may be, than to say that it contains "negative non-carbonate hardness." Even "zero non-carbonate hardness" for all waters in which the total hardness is equal to or less than the alkalinity is a better term than "negative non-carbonate hardness."

New developments in the use of sodium aluminate in the clarification and softening of water justify its receiving more space in another edition of this Manual, as regards both the types on the market and their application in water treatment.

The space devoted to zeolite softening is particularly in need of expansion to provide for discussion of the various kinds of zeolites, the optimum conditions for regeneration, and such modifications as the lime-zeolite process. Emphasis should also be placed on the fact that zeolite softening does not decrease the mineral content of a water, and that for some purposes the sodium salts left are as objectionable as the calcium salts which were removed.

In closing it must be repeated that Mr. Hoover has crowded into this brief chapter an excellent treatment of a complicated subject and that these few criticisms and suggestions are offered only with a view toward helping achieve the maximum usefulness in another edition.

DISCUSSION

HOMER V. KNOUSE, Superintendent, Water Department, Metropolitan Utilities District, Omaha, Nebraska, opened the topic of "Desirable Changes in the Manner of the Discussion of Distribution Systems." Mr. Knouse felt that it was desirable to have more discussion of the economic value of different kinds of pipe. The difference in standard bell sizes of centrifugally cast and other types of cast iron pipes was emphasized. Mr. Knouse was of the opinion that tables giving the Hazen-Williams type of data regarding carrying capacity of pipe should be included in the Manual. He thought that the Hazen-Williams diagrams given in the text were too small for easy use in practice. Mr. W. H. Henby, President, St. Louis County Water Company, St. Louis, Missouri, asked about the raising of pressures at times of fire and the desirable changes in the distribution system on the basis of current practice. Mr. E. J. Stewart, of the Kansas Fire Inspection Bureau, at Topeka, Kansas, and Mr. Thomas F. Wolfe, of the Cast Iron Pipe Research Association of Chicago, agreed that the raising of pressure at times of fire was undesirable. Mr. N. T. Veatch, Jr., of the firm of Black and Veatch, Consulting Engineers, Kansas City, Missouri, and Mr. H. F. Blomquist, Superintendent of Water Works, Cedar Rapids, Iowa, discussed the raising of pressure and their effect on the weakest points in the system. Mr. A. E. Bennett, City Commissioner, Aberdeen, South Dakota, said that he preferred the design diagram as now in the Manual to tables such as those developed by Hazen and Williams. Mr. J. W. McEvoy, Superintendent of Water Works, Dubuque, Iowa, and Mr. J. C. Gordon, Superintendent of Water Works, Independence, Kansas, further discussed the putting on of additional pressure at times of fire, agreeing that the practice was very bad. Mr. Homer V. Knouse, of Omaha, in further discussing the question, mentioned the matter of the sterilization of new mains and insisted that it was essential to satisfactory maintenance of quality. Mr. Thomas J. Skinker, Superintendent of Distribution, Water Department, St. Louis, Missouri, supported Mr. Knouse in statement and said that it would be desirable to emphasize this topic in the Manual. Mr. Jack J. Hinman, Jr., Associate Professor of Sanitation, University of Iowa, Iowa City, Iowa, and Mr. R. Rees, Superintendent of Water Works, Sioux Falls, South Dakota, discussed the disinfection of water mains by the use of chlorine and gave examples of undesirable ex-

periences where such disinfection had been omitted. Mr. N. T. Veatch, Jr., of the firm of Black and Veatch, Kansas City, Missouri, called attention to the great difficulty of trying to say anything about the economic value of different kinds of pipe in a work such as the Manual. He pointed out that there would undoubtedly be commercial opposition to such a procedure.

Water purification was discussed by Mr. L. B. Mangun, Chemist in Charge of Water Purification, Water Department, Kansas City, Kansas. Mr. Mangun said that in his opinion it would be a good idea to have two volumes, one on design and one on operation. He thought that the present treatment of most subjects was too brief to be of a great deal of service either to the inexperienced or to the experienced man. He felt it was too brief for the inexperienced man because he would not understand it. He felt it was too brief to be of great use to the experienced man because the experienced man would naturally know the chief points in the discussion already. He objected to the statement that the condition of the sludge line in sedimentation basins can be known best by noting the condition of effluents. He insisted that soundings should be made to see the position of the sludge line before the quality of the effluents from the basins is in any way affected. Mr. Mangun felt that instead of placing the greatest emphasis, and in fact the only emphasis, on turbidity and bacterial count as control tests in plant operation there ought to be some mention of the tests which are of lesser importance in most localities. He also indicated that the statement that from 60 to 70 per cent of suspended matter is removed in sedimentation basins should be corrected, at least for the plants on the Missouri river. If only 60 or 70 per cent of suspended matter were removed from water of the plant under Mr. Mangun's control, the applied water of the filters would have a turbidity of 1,000 from time to time. Mr. Hinman, the Secretary, called attention to the effect of the different degrees of hardness of the grades of zeolite and the desirability for indicating something of the mechanical strength of the grains of the mineral used in zeolite softening. The extension of the process of zeolite softening of water to municipal plants undoubtedly calls for more careful discussion of this subject in future editions of the Manual.

Topic No. 3 of the discussion, "Water Rates," was opened by Mr. W. H. Henby, President of the St. Louis County Water Company,

St. Louis, Missouri. Mr. Henby said that the data in the book were of great value in order to determine what had been done in earlier cases. Each individual case, however, in determining rates, is a special one and general discussions of principles are therefore highly desirable. This topic was also discussed by Mr. H. F. Blomquist, Superintendent of Water Works, Cedar Rapids, Iowa.

CHAPTER 7 TO 12 INCLUSIVE

The committee has not had an opportunity to arrange a conference on account of the wide separation of its members. A conference would have greatly assisted in preparing an adequate report. All work of the committee has been carried out by correspondence.

On reading Chapters 7 to 12 inclusive, with reference to their revision, it became apparent that the methods of handling the several chapters and the subject matter therein contained varied so greatly that the committee was at once confronted with the question as to what constituted appropriate division, arrangement and treatment.

In the preface to the Manual it is stated:

Although the resulting Manual will be found helpful to all interested in water supply, it has been prepared primarily for the three special groups making up the active membership of the American Water Works Association. These are: (1) the members of water boards and commissions who share the general policies of the water industry; (2) the salaried officials who manage and superintend the works; and (3) the specialists who design, manage or supervise those parts of the work of a highly technical character.

It will appear from this, therefore, that the material should be handled in a very comprehensive way to be useful to all these groups; in fact, thoroughgoing treatises are called for on each subject which treatises, however, must be so handled that they may be read with profit by members of any group. This requires a larger order and a different one to fill without rather precise instructions. Various opinions have been expressed by the members of the committee and others as to what changes in the construction of the Manual are necessary to meet these requirements. Some have said that the Manual should be expanded into two or three volumes or as many as necessary to cover all of the material adequately; others have indicated that the material should be handled with the utmost conciseness, but that elaborate bibliographies should be attached at the

127 DISCUSSION OF MANUAL OF WATER WORKS PRACTICE

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**REPORT OF COMMITTEE OF THE WATER PURIFICATION
DIVISION ON REVISION OF THE MANUAL,
CHAPTERS 7 TO 12 INCLUSIVE¹**

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¹ Presented before the Water Purification Division, the San Francisco Convention, June 14, 1928.

end of each chapter to assist the reader in seeking more detailed information. One member has suggested the inadvisability of attempting to include all the material in a single publication. Instead he favors publishing from time to time treatises dealing with particular phases of water works practice gotten up in a more or less standard form so that these publications may constitute a set of volumes covering the water works field fully. From time to time the individual treatises may be revised to keep them up to date. By this method it is thought that greater concentration of effort can be obtained in the production of complete and reliable treatises. Still others propose one volume of a handbook type suitable for newcomers into the water works field and a second volume more technical in character adapted to the needs of experienced water works operators and technical men.

The next paragraph in the preface gives some additional information on what the Council on Standardization had in mind, as follows:

Inasmuch as the subjects are, in many cases, in a state of flux, in transition from the old to the new, the Council on Standardization has been confronted with the choice of issuing one of two kinds of text. One of these might incorporate the personal viewpoints, judgments and practices of a few individuals, while the other might reflect the principles and practices of a fairly adequate cross-section of practitioners in the multiplicity of water works activities. The Council has chosen the latter policy as the one that would meet most successfully the requirements and perspective of administrator, executive, staff members, student, teacher, and consultant. The adoption of such a policy necessitated obviously a more generalized treatment of some of the text than would otherwise be desirable. General usefulness, however, resulting from a coördination of group judgments, has been the keyword of the undertaking.

From this it would appear that it is the desire of the Council on Standardization to produce a manual which is not the product of individual authorities on various subjects but represents the composite knowledge of a cross section of the society. It would seem obvious, therefore, that material of this sort must be prepared by representative committees. It is difficult to secure the coöperative effort of individual writers in preparing a book that will be well balanced and uniform as to mode of treatment of the various subjects. The difficulty is increased many fold if committees must prepare the material. It therefore becomes apparent that any committees on revision must have very specific instructions as to how the material entrusted to them shall be presented.

The Manual as actually published in 1925 is a valuable book for water works men—in fact quite the most valuable book ever published in this country. It also constitutes a firm basis upon which succeeding manuals can be prepared. Nevertheless the Manual has, and inevitably must have, certain limitations which, however, were clearly recognized by the Council on Standardization as evidenced by the following additional quotation from the preface:

The Manual, as it now appears, can undoubtedly be improved. Such has been the history of the notable Manual of the American Railway Engineering Association. It is to be expected that our Association will similarly develop a keen interest in discussing its Manual in a way to bring about improvements in later editions. In fact, the Manual will doubtless prove an excellent stimulus of discussion at annual conventions and at regional and section meetings throughout the country.

The time has now been reached when the revisions and improvements suggested in the above quotations may be undertaken, but in order that this may be carried out systematically, effectively and with minimum loss of time and effort it is important that the revisions be undertaken by the various committees in conformity with a carefully thought out list of instructions, preferably prepared by the Council on Standardization. Such instructions are not now available and in their absence the committee dealing with chapters 7 to 12 feels that it would be inadvisable to attempt a re-writing of these chapters. It may, however, with some profit present certain general criticisms of the chapters that may constitute a partial basis upon which the Council on Standardization may prepare a suitable list of instructions.

In reading the chapters the most conspicuous general faults are that the subject matter is not properly divided and that it is not handled in a uniform and well balanced manner. For example the material dealing with rapid sand filtration and that dealing with slow sand filtration are treated in quite different ways. The former places principal emphasis on details of design and construction whereas the latter treats with particular reference to operation and maintenance. Both subjects, however, are ably handled within the limits selected by the authors, but they do not seem to belong together in the same manual. Another example of unbalanced treatment is the over-emphasis and mode of presentation of the subject dealing with the use of iodine as a prophylactic against goiter. This

subject might very well have been covered in a few paragraphs in a chapter dealing with sterilization and prophylaxis. Such paragraphs might refer to the application of iodine as a prophylactic measure and give some brief information on methods of application, amount of iodine required and costs. In addition, it would have been permissible to summarize very briefly prevailing opinions for and against its administration through public water supply. Instead, a long chapter has been devoted to the subject which constitutes a rather thorough treatise and an argument in favor of using the public water supply as a means of giving the general public prophylactic treatment.

The committee feels that the material handled in chapters 7 to 12 might advantageously be divided into chapters as follows:

1. A short chapter on treatment of water in general
2. Sterilization and prophylaxis
3. Aeration
4. Plain sedimentation
5. Sedimentation with the aid of coagulants
6. Rapid sand filtration
7. Slow sand filtration
8. Other methods of filtration including household filters
9. Softening of water
10. Removal of iron and manganese

As an appropriate arrangement of chapters dealing with these subjects the committee suggests the following:

- a. Historical sketch.
- b. Statement of what the process is intended to accomplish and what in practice are its general advantages and limitations.
- c. Physics, chemistry, biology and physiology of the process.
- d. Field of applicability.
- e. Description of equipment required for process with illustrations, preferably of a bold diagrammatic character to bring out principles rather than details.
- f. Variations in process to meet varying conditions.
- g. Operation and operation difficulties.
- h. Special devices and important details of design with appropriate illustrations.
- i. Process control including a description of appropriate analytical methods.
- j. Efficiencies and limits of burden to be placed on process.
- k. Costs.

This outline is not intended in any way to be final, but is primarily illustrative of the manner in which uniformity of treatment of the several chapters may be obtained.

The discussions of the committee contain much detail regarding revision of chapters as they now stand, but it is deemed inadvisable to present this material until further instructions are received from the Council on Standardization.

Respectfully submitted,

PAUL HANSEN, *Chairman,*

M. C. WHIPPLE,

W. F. LANGELIER,

H. E. MILLER,

NORMAN J. HOWARD.

EDITORIAL COMMENT

ICE ENGINEERING

The water works engineer is always confronted at this time of the year with the objectionable effects of low temperatures. Difficulties with water supply intakes, pump wells, floating ice and allied disabilities have been the subject of much profanity and the cause of considerable practical adjustments of structures, sometimes with beneficent results. In many instances, however, these disabilities are usually met by expediciencies, largely of local application and rarely of general use. Frequently also the general principles underlying the control of the various forms of ice interference in water works structures have been neither elucidated nor incorporated in the designs.

It is all the more gratifying, therefore, to have available more complete scientific data on the general problem of ice formation and destruction than has hitherto been easily acquired. The contributions on ice engineering by Prof. Barnes supply such a need in the volume entitled "Ice Engineering"¹ issued in 1928. The development and extension by Barnes of a theory of ice formation are not only fascinating, but of considerable practical importance. When it is conceived that water, a compound so long familiar to the water works practitioner, is a complex rather than a simple liquid, containing ice at virtually all temperatures, the water works superintendent is provided with a working hypothesis which makes his intelligent control of ice accumulations far simpler than hitherto. Barnes points out,² for example, that when water is boiled for tea, ice water is literally being boiled, even though the ice cannot be seen even microscopically until the freezing point is reached, at which point the ice becomes a colloidal suspension in the water. Water is already almost 40 per cent ice before it freezes. The analogy with the familiar phenomena of coagulation is pointed out by Barnes, in his emphasis upon the fact that water is frozen with difficulty, in capillary tubes, for instance, when there is no nucleus to start the coagulation in the ice. Under most natural conditions, there are a sufficient

¹ Barnes, Howard T., Renouf Publishing Company, Montreal, Can., 1928.

² Barnes, Howard T., Ice Engineering, Jour. Boston Soc. Civ. Eng., 15, 7: 319, September, 1928.

number of fine particles such as weeds, dust or sand in suspension which offer opportunities for the production or coagulation of the solid ice.

The second important principle enunciated is the fact that a minute change in temperature is required to start the coagulation of these ice particles. As long as water remains at 32° the ice flows in a colloidal solution. If the temperature falls, however, one thousandth of a degree or less below freezing, it begins to form solid ice. The converse of this principle is of practical importance, namely that an exceedingly small temperature elevation, or about one thousandth of a degree above freezing, will usually prevent the formation of solid ice. The importance of this principle in the protection of water supply intakes, racks and screens is apparent.

Upon the basis of these principles, practicable procedures have been developed for the control of ice formation and for the destruction of ice growths through the use of steam, thermit, hot water, calcium chloride and other chemicals. Practical applications of these principles, known or unknown, naturally have been at hand for many years. The importance of the present theories lies in the opportunities for more intelligent prevention and control than have been available in previous years.

For example, Reed³ recently gives comparative data on the methods of combating ice and low temperature at hydro plants in Norway. At one of these plants, he reports that, during the first years of operation, hand rakes or scrapers were used to clear the intake. The rack bars were about 28 feet long and it was nearly impossible to keep them clear. During the winter season 100 to 120 men were employed in this way. In 1913, electrical heating of the rack bars was first tried. It has proven very successful and only one man is now required to take care of the entire forebay. The system is in use at Kykkelsrud, Vamma, Raanaasfos, Lerfos and Hafslund in Norway, and in Trollhatten in Sweden.

Reed³ points out that heating of the racks with steam has been tried but has not been very successful. In such installations the racks are hollow and contain steam pipes. Mechanical racks were also tried without success.

ABEL WOLMAN.⁴

³ Reed, Oren, Combating Ice and Low Temperature at Hydro Plants in Norway, Eng. News-Record, 101, 22: 805, November 29, 1928.

⁴ Editor-in-Chief, Journal American Water Works Association; Chief Engineer, Maryland Department of Health.

SOCIETY AFFAIRS

MISSOURI VALLEY SECTION

The fourteenth annual meeting of the Missouri Valley Section was called to order by Chairman Thomas J. Skinker in the Ball Room of the Kansas City Athletic Club at Kansas City, Missouri, October 2, 1928, at 10:30 a.m. There were 83 persons present. Honorable A. I. Beach, Mayor of Kansas City, Missouri, addressed the Section and officially welcomed them to Kansas City. Honorable Don C. McCombs, Mayor of Kansas City, Kansas, who was to have addressed the Section, was unable to be present, and his place was taken by Honorable A. H. Strickland, Commissioner of Water, Light, and Power, of Kansas City, Kansas. Mr. Strickland spoke on behalf of the city and of his Department. In the absence of William F. Fleming, Director of the Water Department of Kansas City, Missouri, George F. Gilkison extended the hospitality of the Water Department. Thomas J. Skinker, Engineer in Charge of Distribution of the Water Department of St. Louis, Missouri, and the Chairman of the Missouri Valley Section, replied to the addresses of welcome which had been given. Mr. Skinker then introduced Mr. Beekman C. Little, Secretary of the American Water Works Association, who spoke to the Section on the work of the American Water Works Association. Mr. Little stressed the importance of the Journal of the Association, of the Manual of Water Works Practice issued by the Association, and the research work undertaken by that organization. Following Mr. Little's remarks H. F. Blomquist called attention to the presence of William Molis, Superintendent of Water Works at Muscatine, Iowa, and one of the oldest members of the Association in point of length of membership. Mr. Molis then told the session something about his early experiences at water works meetings and the kind of work carried out at the meetings immediately following the organization of the Association at St. Louis nearly fifty years ago.

Topic Number One, "Fire Sprinkling Service Lines," was then introduced by J. W. McEvoy. The topic was discussed by Thomas

J. Skinker, H. V. Pederson, J. Chris Jensen, John W. Pray, C. L. Ehrhart, W. V. Weir, Harry J. Corcoran and W. L. Meeker. At the conclusion of the round table discussion it was moved by G. E. Shoemaker and seconded by J. W. McEvoy that it was the consensus of opinion of the meeting that fire sprinkler service connections should be metered with a type of meter approved by the Fire Underwriters and that the metering should be at the expense of the consumer, with the cost of the water used and the cost of necessary inspection also to be charged to the consumer. The motion was carried.

The afternoon session of October 2 was opened by Thomas J. Skinker, Chairman. The first paper, by H. V. Pedersen, entitled "Doing Water Works Improvements on a Cost Plus Basis" was read and discussed. Those taking part in the discussion included: C. M. Gillam, John J. Myrtue, John W. Pray, George E. Shoemaker and Harry J. Corcoran.

Earle L. Waterman, being absent on account of sickness, his paper entitled "Ground Waters vs. Surface Waters as Sources of Municipal Water Supply" was read by title.

The paper entitled "Construction of a Distribution System" by C. L. Ehrhart, was next read. This very practical paper was discussed at considerable length by the members of the Section. Among those taking part in the discussion were: H. F. Blomquist, Thomas J. Skinker, W. V. Weir, H. V. Pedersen, J. W. McEvoy, William Molis, George E. Shoemaker, J. C. Gordon, and F. L. Thierfelder. C. L. Ehrhart, in closing the discussion of his paper, answered a number of questions which had been propounded by those who had discussed the matter.

R. L. Baldwin next read his illustrated paper on the subject of "Motor Drive for Pumping Water." The paper was discussed by H. V. Pedersen, John W. Pray, William Molis, F. L. Thierfelder, and by Beekman C. Little.

Upon the completion of the discussion of Mr. Baldwin's paper the Section returned to the Round Table Discussion, taking up Topic No. 2, "Should Each Building Have a Separate Service Connection?" The discussion of this topic was introduced by H. F. Blomquist, and the following individuals took part in the extensive discussion which followed: R. Rees, George E. Shoemaker, J. W. McEvoy, W. V. Weir, F. L. Thierfelder, C. E. Gillam, C. T. Hough, J. C.

Gordon, H. V. Pedersen, Jerome Powers, Thomas J. Skinker, Frank Lawlor, W. L. Meeker and Beekman C. Little.

Thomas J. Skinker, the Chairman: then appointed the following committees to function during the meeting: Nominating Committee: N. T. Veatch, Jr., Chairman: J. W. McEvoy, Ernest Boyce, C. D. Hays. Resolutions Committee: Frank Lawlor, Chairman, R. Rees, B. L. Ulrich, L. A. Day. Auditing Committee: H. V. Pedersen, Chairman, H. L. Brown, R. N. Lawrence, W. V. Weir.

The meeting adjourned at 5:00 p.m.

The evening session of October 2 opened at 8:00 p.m. with Vice Chairman John W. Pray, presiding. E. B. Black read his paper entitled "Water Works Valuation for Rate Making Purposes." This was followed by the paper by Clarence Goldsmith, on the subject of "The Relation of Municipal Water Works Systems to Public Fire Protection." This paper was briefly discussed by George E. Shoemaker.

Dr. Earle G. Browne, Secretary and Executive Officer of the Kansas State Board of Health, Topeka, Kansas, read his paper on "The Economic Value of Public Health Protection." The paper was briefly discussed by Jack J. Hinman, Jr., the Secretary of the Section.

The meeting was then adjourned.

The morning session of October 3 was opened by Chairman Thomas J. Skinker at 9:40 a.m. About seventy-five persons were present in the room. This session was devoted to a special discussion of the Kansas City, Kansas, Water Plant. Papers were read as follows:

1. "Accounting and Financing for a City's Utilities" by A. H. Strickland. This paper was discussed by J. W. McEvoy and H. F. Blomquist.

2. "Advantages and Economies of a Combined Water and Power Plant" by J. D. Donovan. This paper was discussed by L. A. Day.

3. "Kansas City, Kansas, Filtration Plant Improvements and Extensions" by Charles A. Haskins. This paper was discussed by H. F. Blomquist, L. B. Mangun, John D. Fleming, and Frank Lawlor.

4. "Special Features of Handling and Applying Chemicals," Kansas City, Kansas," by L. B. Mangun. This paper was illustrated by lantern slides and diagrams. It was discussed by C. O. Bates.

5. "Extension Program of the Kansas City, Kansas, Plants" by

Arthur L. Mullergren. On account of the fact that buses were waiting to take the party to the plant of the Kansas City, Kansas, Water Department, it was not possible to have a discussion of Mr. Mullergren's paper.

Buses for the members of the Section took the party, under police protection, to the Quindaro Water Plant of the Kansas City, Kansas, Water Department. A delightful luncheon was served in the old filter house of the Quindaro Plant by courtesy of the Water Department of Kansas City, Kansas. About two hundred and fifty-five individuals sat down to the luncheon. During the luncheon a photograph was taken of the group. Chairman Thomas J. Skinker expressed to the members of the Water Department the thanks of the Section for the courtesy.

Following the luncheon a visit to the different parts of the Quindaro Plant was undertaken, after which, at the signal of two blasts of the whistle of the plant, the party gathered near the entrance to have a panorama picture taken of the crowd. After leaving the plant of the Water Department the party was taken to the works of the Palmolive-Peet Company in Kansas City, Kansas, where the making of Crystal White and Palmolive soap was explained and demonstrated. After leaving the plant of the Palmolive-Peet Company the party was taken to the Kansas City Structural Steel Company mill and enabled to see the plant at work. After the inspection of the steel mill the members of the Section were returned to the Kansas City Athletic Club in the cars which took them out.

At 6:30 on the evening of October 3 the ladies attending the meeting were tendered a dinner at the Kansas City Club by the Ladies Entertainment Committee. Following the dinner a theatre party at the Midland Theatre was enjoyed.

At 8:00 o'clock there was a smoker for the men who were attending the meeting on the fifth floor of the Kansas City Athletic Club.

C. L. Ehrhart, Director of the Section, presided at the opening meeting on October 4. William T. Bailey, read a paper entitled "The Use of Electrolytic Cells in Chlorination for the Destruction of Algae in Settling Basins." Mr. Bailey's paper was discussed by C. C. Bates, F. G. Merkel, and J. C. Gordon.

Max Levine was not present to read his paper on "Notes on Bacterial Synergism and the Presumptive Test for the Colon Group." His paper was therefore read by title.

The film entitled "The Chemistry of Water Treatment, Illustrated"

was shown by George W. Paulette. The film was discussed by Selma Gottlieb and John D. Fleming.

The next paper was entitled "The Determination of Cyanides in Water and Sewage" by Jack J. Hinman, Jr. and Samuel D. Poarch. This paper was discussed by Selma Gottlieb and John D. Fleming.

N. P. Sherwood, of the Department of Bacteriology of the University of Kansas, Lawrence, Kansas, next read a paper by himself and Dr. Brewster, of the Chemistry Department of the same institution on the subject of "Chlorination by Means of Chlorinated Air." This paper was illustrated by lantern slides carrying the data in tabular form.

Following Dr. Sherwood's paper Topic No. 5 of the Round Table Discussion, "Water Waste Surveys" was introduced by Jerome Powers. The topic was also discussed by Thomas J. Skinker, John W. Pray, W. A. Henby, H. V. Pedersen, W. L. Meeker, H. F. Blomquist, A. E. Bennett, R. Rees, Frank Lawlor and W. H. Vaughn.

The meeting adjourned at 11:50 a.m.

The meeting of the afternoon of October 4 was devoted to a discussion of the Manual of Water Works Practice.¹

The Missouri Valley Section then went into a business session. H. V. Pedersen, Chairman, reported for the Auditing Committee that they had examined the books and vouchers of the Secretary-Treasurer and found them to be correct in every particular. The report was accepted.

Frank Lawlor, for the Resolutions Committee, presented the following resolutions:

1. Whereas we believe that this Fourteenth Annual meeting of the Missouri Valley Section of our Association is a time for mutual congratulations on the growth of the section and on this very successful meeting now coming to a close we believe it is a suitable time to place on record our appreciation of our indebtedness to our retiring Secretary-Treasurer, Mr. Jack J. Hinman, Jr., who for thirteen years has served the Iowa Section so faithfully and so well. We therefore propose that a vote of thanks be extended to him, and that this expression of our appreciation be entered on the Minutes of the meeting. We also move that the Section congratulate Mr. Hinman on his election to the office of Vice President of the national association. (This motion was duly accepted and carried.)

2. Whereas we are much indebted to all those who have contributed in any way to our entertainment in connection with the Fourteenth Annual Meeting

¹ This Journal, page 114.

of the Missouri Valley Section of the American Water Works Association, be it resolved that we express our appreciation to the officials and the people of Kansas City, Kansas, and Kansas City, Missouri, for the courtesy extended and for the pleasant impressions and remembrances we will take to our homes with us. Resolved that the thanks of the Section be extended to all the officials of the Kansas City, Missouri, and Kansas City, Kansas, administrations, especially to the Mayors and Commissioners of those cities and the police departments and the water departments, who contributed so much to our safety and pleasure at the meeting.

3. Resolved that the thanks of the meeting be extended to Mr. N. T. Veatch, Jr., to Mrs. Eric W. Bacharach, and to all the members of their very efficient local committees, who have established records that will endure in the entertainment of the water works conventions.

4. Resolved that the thanks of the meeting be extended to the Kansas City Athletic Club and especially to Mr. R. F. Marsh, Manager, who contributed so much to our comfort.

5. Resolved that the thanks of the meeting be extended to Mr. Clarence Goldsmith, of the National Board of Fire Underwriters, of Chicago, Illinois, to Dr. Earle G. Browne, of the Kansas State Department of Health, and to Dr. N. P. Sherwood and Dr. Brewster, of the University of Kansas, at Lawrence, for the valuable paper prepared and presented by them.

6. Resolved that we extend a hearty welcome to the new members from the great state of Kansas which has now become a part of the Missouri Valley Section. The original members of the Section are delighted to have the Kansas Water Works men unite with them and wish to express a hope that they may get the greatest benefit and pleasure in the work of the Section. It is hoped that they will be present in even greater numbers at succeeding meetings.

7. Resolved that the meeting express its pleasure at the presence of Mr. Beekman C. Little, Secretary of the American Water Works Association, whose attendance at the meeting added much to the pleasure of the affair. It is the opinion of the members of the Missouri Valley Section that Mr. Little's presence at Sectional meetings will do much to cement the bond of union between the Sections and the national association.

8. Resolved that the Missouri Valley Section express its appreciation of the courtesies extended by the Palm-Olive Peet Company, of Kansas City, Kansas, and by the Kansas City Structural Steel Company, of Kansas City, Kansas, for their kindness in opening their plants for the inspection of the members of the section.

9. Resolved that all these resolutions be entered in the Minutes of the Fourteenth Annual Meeting of the Missouri Valley Section and that the Secretary be instructed to send the customary letters of thanks to all parties mentioned therein.

The resolutions as presented were approved by the Section and the motions included therein were carried.

Mr. Lawlor read a letter from Charles R. Henderson, Chairman of

a committee appointed by Mr. Thomas J. Skinker, Chairman of the Section, to present Mr. Hinman, the retiring secretary, with a testimonial of appreciation of his work during the time he had served the Section as its Secretary-Treasurer. The letter was accompanied by a check for \$200.00. Mr. Hinman thanked the Section in a short speech.

The Nominating Committee by N. T. Veatch, Jr., its Chairman, presented the following slate for the officers for the ensuing year: For Chairman, John W. Pray; for Vice Chairman, Thomas D. Samuel, Jr.; for Directors, Hans V. Pedersen, H. L. Brown. It was moved by H. F. Blomquist, seconded by Frank Lawlor, that the report of the Nominating Committee be accepted, and that the Secretary be instructed to cast a unanimous ballot for the officers proposed. The motion was carried.

Mr. Veatch then presented a motion calling for a change in the constitutional method of electing directors. Mr. Veatch proposed that a director from each state be elected by a letter ballot circulated among the members living in that state. He also recommended that the manufacturers interested in the conduct of the work of the Missouri Valley Section be invited to select a representative from among themselves to conduct such negotiations as are required between manufacturers agents and the officers of the Section.

Mr. Veatch also proposed that a change be made in the manner in which the Nominating Committee of the Section is appointed. Heretofore it has been customary to appoint the Nominating Committee at the beginning of the session. They have then reported at the regular business meeting of the Section and a vote has immediately been taken upon the officers for the ensuing year. Mr. Veatch's proposal was to appoint the Nominating Committee at the business session of the meeting and let the Nominating Committee so appointed report at the business meeting on the first day of the following convention. Nominations could be made from the floor at the time of the actual election, which would take place on the afternoon of the first day of the section meeting. In case of the death or removal by other cause of the nominee before the time of the meeting at which the election was to take place, the vacancy could be filled by subsequent nominations by the nominating committee. Mr. Veatch proposed that the secretary and the incoming Executive Committee revise the existing constitution of the Section so as to take these points into account. The proposed revision of

the constitution should be submitted to the membership of the Section and also to the Executive Committee of the American Water Works Association as is required. Steps as laid out in the existing constitution for the adoption of changes in the constitution of the section should then be taken in order that the proposed method of electing officers shall be made the legal one. Mr. Veatch's motion was seconded and carried.

Mr. Hinman, the Secretary, then read a letter from R. L. Dobbin, Chairman of the Committee appointed by President W. H. Brush, of the American Water Works Association, to revise the existing constitution. In discussing the proposed changes in the constitution, that portion calling for three regional meetings of the Association per year came in for violent opposition on the part of a number of members of the Section. It was felt that instead of being of assistance to the small water works operators as the regional meetings had been intended to be, they would instead work a hardship on the small water works men. It was felt that there would be too large distances from one of the regional meetings to another and that the trip necessary to attend these meetings would be too great for the small water works operator. It was also felt that the attendance at regional meetings would reduce the importance of the section meetings which offer at the present time the best way to interest the small water works operator in the work of the parent association. It was also felt that the danger of sectionalization of the country or provincialism among water works men would be fostered by the regional meetings. It seemed hardly likely that many of the members would attend more than one regional meeting per year even if they were able to attend a single regional convention. This being the case, these men who attended regional meetings would not get in touch with men from the other regions and consequently would suffer by the failure to broaden themselves by contact with men from a distance and men faced by problems dissimilar to their own. Those taking most part in this discussion were H. F. Blomquist, H. V. Pedersen, J. W. McEvoy and Frank Lawlor. It was moved by Mr. Pedersen, seconded by Mr. McEvoy, that the Section express formal opposition to the plan of substituting for the annual meeting as now held, three regional meetings, one of which was to function as the annual national convention. After some discussion it was proposed by Frank Lawlor, that the actual vote on this question be postponed until the morning session of October 5. With

the approval of the maker of the original motion and his second the vote was therefore postponed. (On account of the volume of business at the meeting on the following morning the vote was never taken.)

The Secretary then read several letters and telegrams from clubs and other organizations of Sioux Falls, South Dakota, inviting the Section to hold the Fifteenth Annual Meeting at that city. R. Rees, being present at the session, formally invited the Section to hold its Fifteenth Meeting at Sioux Falls, South Dakota. George E. Shoemaker, also invited the Section to hold its Fifteenth Annual Meeting in Waterloo, Iowa. Hans V. Pedersen invited the Section to hold its next meeting in Marshalltown. After some discussion it was agreed to postpone the decision until the morning of October 5. (Sufficient time not being available on October 5, the matter of the choice of the next meeting place was left to the incoming Executive Committee with power to act.)

The business meeting then adjourned.

At 7:30 p.m., on the evening of October 4 the Missouri Valley Section, jointly with the Kansas City Engineers' Club, enjoyed a dinner dance on the twenty-second floor of the Kansas City Athletic Club. Dinner was served on the promenade around the ball room. A very pleasant evening was spent by those in attendance.

The morning session of Friday, October 5, was called to order at 9:50 by Chairman Thomas J. Skinker. The first paper on the program was entitled "Water Supply System of Kansas City, Missouri" by T. D. Samuel, Jr.

In the absence of Charles S. Foreman, his paper on the subject of "Missouri River and Turkey Creek Pressure Tunnels" was read by A. H. Zeitz.

Mr. Forman's paper was followed by a paper entitled "Chemical Treatment of the Kansas City, Missouri, Water Supply" by George F. Gilkison. Dr. Gilkison's paper was discussed by C. O. Bates, William T. Bailey and L. B. Mangun.

The fourth paper was entitled "Electrical Pumping at Kansas City, Missouri" by A. L. Maillard.

Following Mr. Maillard's paper a paper entitled "Pools and Pools" by Arthur Morton Crane was read by title.²

The Section then adjourned at 11:30 a.m.

Automobiles were waiting for the members of the Section who were taken to the new water purification plant of Kansas City.

² This Journal, page 107.

Missouri, in North Kansas City. Luncheon was served in the filter building, following which the members of the Section were taken for an inspection of the plant. After the inspection of the water purification plant of the city of Kansas City, Missouri, the meeting was concluded.

J. J. HINMAN, JR.,
Secretary.

WISCONSIN SECTION

The seventh annual meeting of the Wisconsin Section was held in the new Memorial Hall in Menasha, on October 11 and 12, 1928. There was a total registration of 120, including 81 waterworks superintendents, engineers, commissioners, etc., 24 manufacturers' representatives and 15 ladies.

A considerable portion of the time at the convention was taken in discussing three features which are beginning to receive attention from water works men. They are—Advertising the Water Works, and the paper presented by A. J. Hall of Appleton, entitled "Selling the Water Works to the Public" was discussed very freely. A good many suggestions were made, such as having school children go through the water works plant, and keeping the public in touch with the operation of the water works by newspaper publicity.

The second one, which is a rather new item, was the proposal of taking care of water works employees whose period of usefulness is at an end. The paper by L. A. Smith, on Water Works Pension Systems³ furnished the basis for discussion, and along the same line a paper by P. J. Hurtgen, on Group Insurance for Water Works Employees,⁴ was of interest.

The third item which received considerable attention was the matter of proper filter plant operation. The paper by L. F. Warrick offered the basis for this discussion, and the particular details of operation were well illustrated in the new filter plant which has recently been completed, at Menasha.

Mr. Adolph Kannenberg, of the Railroad Commission at Madison, presented a paper on the proper relations which should exist between the waterworks utility and the municipality, calling attention to the necessity of keeping separate books and keeping an accurate record of the services furnished the water department by the municipality,

³This Journal, page 31.

⁴This Journal, page 35.

as well as the services furnished to the municipality by the water department. He called attention to the necessity of proper provision for depreciation, as well as methods of financing water works construction. He made a very vigorous argument against surplus funds of the water department being diverted to the general fund.

The San Francisco convention trip was discussed by W. G. Kirchoffer.

Other papers of note were, Maintenance of Meters by Frank J. Murphy; Deep Well Pumping, by A. W. Hebbring; and the Water Waste Survey at Wisconsin Rapids, by C. P. Gross.

Mr. Frank R. Daniels, Chief Engineer of the Wisconsin Inspection Bureau of Milwaukee, discussed water works construction and operation from the viewpoint of the Inspection Bureau calling attention to the necessity of proper size mains and hydrants and adequate inspection of hydrants and valves.

The next meeting will be held in Kenosha next year.

The new officers are P. J. Hurtgen, Chairman; H. W. Jackson, Vice Chairman; Geo. A. Corine, Director. The other Director is the past Chairman, A. J. Hall. L. A. Smith was reelected Secretary-Treasurer for the coming year.

L. A. SMITH,
Secretary-Treasurer.

A New Arc Welding Process. M. ZACK. Schmelzschweissung, 6: 8-11, 1927; Chimie et industrie, 18: 430, 1927. From Chem. Abst., 22: 376, February 10, 1928. Process consists essentially in use of 2 different electrodes, one of carbon and other of metal. Three arcs are formed, one between the two electrodes and one between each electrode and piece to be welded. With alternating current a higher stability of arcs is obtained with small current consumption.—R. E. THOMPSON.

Chemical Purification of Industrial Waters by Precipitation. A. LANGMUIR. Ars et métiers, 84: 326-32, September, 1927. From Chem. Abst., 22: 470, February 10, 1928. Outline of various processes and description of equipment used for slow precipitation by lime-soda, for rapid precipitation by lime-soda, and for purification by continuous blow-down of boilers, showing that second is most rational and efficient.—R. E. THOMPSON.

Vacancies on the abstracting staff occur from time to time. Members desiring of cooperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 235 Willow Avenue, Toronto 2, Ontario, Canada.

ABSTRACTS OF WATER WORKS LITERATURE¹

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Corroded Condenser Tubing; Reducing Further Corrosion as much as Possible. BR. SCHULZ. *Korrosion u. Metallschutz*, 3: 222-7, 1927. From Chem. Abst., 22: 376, February 10, 1928. Discussion of brass condenser tube corrosion as affected by materials of construction, cooling water, and condenser operation. Special mention made of using permutit water softeners to prevent scale formation as opposed to cleaning out tubes in which scale has formed with hydrochloric acid.—R. E. Thompson.

A Study of the Penetration of Corrosion-Preventive Iron-Mica Films by Water. A. KIRSCH. *Korrosion u. Metallschutz*, 3: 227-9, 1927. From Chem. Abst., 22: 376, February 10, 1928. Method described for testing permeability of paint films in water. Reservoir of copper sulfate solution on one side of film was kept at slightly higher pressure than pure water on other side. Analysis of water for copper gives means of estimating permeability.—R. E. Thompson.

A New Arc Welding Process. M. ZACK. *Schmelzschweissung*, 6: 8-11, 1927; *Chimie et industrie*, 18: 459, 1927. From Chem. Abst., 22: 376, February 10, 1928. Process consists essentially in use of 2 different electrodes, one of carbon and other of metal. Three arcs are formed, one between the two electrodes and one between each electrode and piece to be welded. With alternating current a higher stability of arcs is obtained with small current consumption.—R. E. Thompson.

Chemical Purification of Industrial Waters by Precipitation. A. LANGUMIER. *Arts et métiers*, 84: 326-38, September, 1927. From Chem. Abst., 22: 470, February 10, 1928. Outline of various processes and description of equipment used for slow precipitation by lime-soda, for rapid precipitation by lime-soda, and for purification by continuous blow-down of boilers, showing that second is most rational and efficient.—R. E. Thompson.

¹ Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

The Water Supply of Durban, Natal, with Special Reference to the Shongweni Scheme. W. M. CAMPBELL. *Water and Water Eng.*, 29: 349-51, 1927. From Chem. Abst., 22: 469, February 10, 1928. Shongweni scheme consists of storage reservoir of 2600 million gallons capacity on Umlaas River, 20-mile aqueduct of 20 m.g.d. capacity, sedimentation tank and 16 rapid sand filters of Paterson type of 10 m.g.d. total capacity.—R. E. Thompson.

Quality of the Surface Waters of New Jersey. W. D. COLLINS and C. S. HOWARD. U. S. Geol. Survey, Water Supply Paper, 596-E: 89-119, 1927. From Chem. Abst., 22: 469, February 10, 1928. Analyses of 121 samples tabulated.—R. E. Thompson.

Diurnal Variations of the Gaseous Constituents of River Waters. R. W. BUTCHER, F. T. K. PENTELOW, and J. W. A. WOODLEY. *Biochem. J.*, 21: 945-57, 1927. From Chem. Abst., 22: 470, February 10, 1928. During day oxygen is at maximum, ammoniacal nitrogen at minimum, and pH value at maximum. During night the reverse is true.—R. E. Thompson.

Dissolved Gases in Waters of Some Puget Sound Bogs. G. B. RIGG, T. G. THOMPSON, J. R. LORAH, and K. T. WILLIAMS. *Botan. Gaz.*, 84: 264-78, 1927. From Chem. Abst., 22: 470, February 10, 1928. Wet bogs contain methane; dry bogs do not. Wet bogs contain greater concentrations of carbon dioxide than the dry bog. Oxygen content in all samples of bog water is practically nil.—R. E. Thompson.

Simple Routine Bacteriological Tests of Ground and Spring Water. M. NEISSER. *Gas- u. Wasserfach*, 70: 1043-5, 1927. From Chem. Abst., 22: 470, February 20, 1928. Frequent tests for *B. coli* (indole formation) suggested. Such tests would be subject to confirmation by other sources when positive test was secured. Suggestions made as to technique.—R. E. Thompson.

The Variation in Hardness of Thames and Kennet (Berks) Waters During the Rainy Seasons. W. L. DAVIES. *Water and Water Eng.*, 29: 366-8, 1927. From Chem. Abst., 22: 470, February 10, 1928. Temporary and permanent hardness of waters of rivers flowing over Cretaceous areas vary inversely as rainfall, rainfall of 1 inch above average causing depression of roughly 15 per cent below mean value. Low water temperatures and heavy rain collaborate in lowering both hardnesses, while high temperature and heavy rain make the depression less acutely defined. Permanent hardness increases with rise of temperature to greater extent than temporary hardness. Permanent hardness quickly recovers after depression due to heavy rain and remains constant during spells of uniformly wet or settled weather. Higher water temperature with increased rainfall does not appreciably affect constancy of permanent hardness values. Constancy of hardness in river waters of this description depends on quickness of rivers in recovering normal conditions of flow and temperature. Amount of permanent hardness depends on rate of flow and on character of rocks of areas drained. Alkali and total calcium vary directly with temporary and total hardness respectively. Ease of river ridding itself of suspended

matter depends on rate of flow or on its quickness in recovering normal state.—*R. E. Thompson.*

Sand Filter Plant, Launceston, Tasmania. G. D. BALSILLE. *Commonwealth Eng.*, 15: 95-8, 1927. From *Chem. Abst.*, 22: 471, February 10, 1928. Water is taken from St. Patrick's River, passing through mortar-lined channel in which green algae growths are sometimes so profuse that flow is reduced. It has been observed that the algae grow at alkalinities below 17 p.p.m., and disappear at alkalinities above 18 p.p.m. Caddis worms, larvae of fly of dragon family, feed on and destroy the algae. Fresh soda is used to raise alkalinity when it is too low for efficient treatment on the sand filters. Color is the index to show practical operation. Reduction throughout year was 90 per cent.—*R. E. Thompson.*

Notes on the Determination of Dissolved Oxygen in Water. V. G. ANDERSON and J. R. DICKSON. *Chem. Eng. Mining Rev.*, 19: 467-8, 1927; cf. *C. A.*, 8: 1841. From *Chem. Abst.*, 22: 472, February 10, 1928. Attention is directed to modification of the Miller-Linossier method of determining dissolved oxygen in water. Titration is carried out in large Nessler tube. For field work a large separatory funnel can be employed. Sample is drawn up through stem and kept from contact with air by means of layer of paraffin oil. From funnel sample is allowed to run into Nessler tube through stem, which should extend to bottom of tube and dip below layer of paraffin oil. To 50 cc. sample thus transferred, add 5 cc. alkaline tartrate solution (60 grams sodium hydroxide and 173 grams Rochelle salt in 500 cc. distilled water) and 1 drop methylene blue indicator solution (1 gram per liter). Reagents are added by means of pipettes dipping underneath paraffin layer. Gently stir by means of a plunger and from burette add standard ferrous ammonium sulfate (0.3103 grams $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ and 1 cc. concentrated sulfuric acid made up to 100 cc. with distilled water) until blue color is just discharged. Tip of burette is joined to capillary tube about 15 cm. long which dips below surface of sample during titration. Burette readings give number of cubic centimeters oxygen per liter. Ferrous solution should be standardized against distilled water of known oxygen content, which can be obtained by shaking distilled water with air until saturated, observing temperature and referring to dissolved oxygen tables.—*R. E. Thompson.*

Oxygen Determination in Potable and River Water. L. W. HAASE. *Gas-u. Wasserfach*, 70: 1065-7, 1927. From *Chem. Abst.*, 22: 472, February 10, 1928. Errors in determination of oxygen in water by means of manganous hydroxide are noted. Care must be taken to avoid undue agitation in taking sample and to avoid long standing, especially at a higher temperature. Manganous chloride should be added before the solid sodium hydroxide or results will be too low. Traces of nitrite give high results but can be removed with few drops of sodium azide solution.—*R. E. Thompson.*

A Simple Colorimetric Method for Field Determination of the Carbon Dioxide Tension and Free Carbon Dioxide, Bicarbonates, and Carbonates in Solution in

Natural Waters. II. A Critical Mathematical Analysis of Theory and Data. E. B. POWERS and J. D. BOND. *Ecology*, 8: 471-9, 1927; cf. *C. A.*, 21: 3242. From *Chem. Abst.*, 22: 471, February 10, 1928. Formula developed and discussed.—*R. E. Thompson.*

Microchemical Experiments on Iodine in Beverages and Foods. MARIO SETTIMI. *Ann. chim. applicata*, 17: 426-32, 1927. From *Chem. Abst.*, 22: 471, February 10, 1928. Data on 6 Roman waters obtained with analytical method of FELLEBERG (*C. A.* 17, 2717; 19, 1109, 1466). No proportionality was found between hardness and iodine content, as concluded by CHATIN (*Compt. rend.* 30-39, 46, 50, 82 (1850-76) after numerous analyses.—*R. E. Thompson.*

Protection Against Corrosion and Boiler Scale by Electric Currents. W. PHILIPPI. *Apparatebau*, 39: 282, 1927. From *Chem. Abst.*, 22: 471, February 10, 1928. Such protection is not sufficient with complicated boiler construction and impure water.—*R. E. Thompson.*

The Biological Effect of Colored Glass Windows in Water Works. R. KOLKOWITZ. *Gas- u. Wasserfach*, 70: 1118, 1927. From *Chem. Abst.*, 22: 471, February 10, 1928. Use of colored glass windows, especially green, results in marked decrease in formation of algae and mosses on wooden parts and walls.—*R. E. Thompson.*

Swimming Baths: The Dangers of Pollution and the Measures for Prevention. J. GRAHAM FORBES. *J. State Med.*, 35: 595-607, 1927. From *Chem. Abst.*, 22: 473, February 10, 1928. Discussion of various types of infection which may arise from swimming pool pollution, and, briefly, the bacteriological and chemical control, disinfection, and importance of maintaining transparency of the water.—*R. E. Thompson.*

Studies on the Dissolved Oxygen Absorption Test. II. E. A. COOPER and W. H. READ. *J. Soc. Chem. Ind.*, 46: 413-4T, 1927; cf. *C. A.*, 21: 2520. From *Chem. Abst.*, 22: 472, February 10, 1928. Consideration of tabulated results shows that presence of small quantities of sodium permolybdate, e.g., concentrations of 1 in 10,000, causes very considerable increase in rate of dissolved oxygen absorption, amount of oxygen taken up being sometimes increased ten-fold. Dissolved oxygen absorption in two days in presence of permolybdate tends to be of same order as absorption in five days in absence of this catalyst but final conclusions must await further investigation which authors indicate. Action of permolybdate is quite specific. Sodium permolybdate perceptibly increases rate of dissolved oxygen absorption by solutions of tartrate in tap water. Permolybdate cannot be used to intensify action of hydrogen peroxide itself on sewage effluents.—*R. E. Thompson.*

The Determination of Iodine in Natural Waters. J. F. MCCLENDON. *Proc. Soc. Exptl. Biol. Med.*, 24: 389-91, 1927. From *Chem. Abst.*, 22: 472, February 10, 1928. Quantitative method described in detail in original.—*R. E. Thompson.*

Degassing Water. D. S. JACOBUS. U. S. 1,650,129, November 22. From Chem. Abst., 22: 473, February 10, 1928. Water for use in boilers or for other purposes is first boiled under reduced pressure and then passed over oxidizable material such as iron.—R. E. Thompson.

Combustion Control Formulas. I. Introduction. II. The Pound Carbon Fuel Unit. E. A. UEHLING. Power, 66: 880-1, 970-2, 1927. From Chem. Abst., 22: 492, February 10, 1928. Unit is defined as that weight of fuel containing 1 pound of carbon. It is nearly equicalorific for each of several types of fuels.—R. E. Thompson.

Alignment Chart for Determining Minimum Combustion Air and Maximum Carbon Dioxide. C. ALBERT KULMANN. Power, 66: 710-1, 1927. From Chem. Abst., 22: 492, February 10, 1928. Chart is based on usual equations and requires knowledge of the oxygen, sulfur, hydrogen, and carbon contents of the fuel.—R. E. Thompson.

Guiding Boiler Operation from Carbon Dioxide and Uptake Temperature. G. B. MULLOY. Power, 66: 660-2, 1927. From Chem. Abst., 22: 492, February 10, 1928. Armour and Company save 90,000 tons of coal annually by maintaining clean and tight boilers, proper sizing of coal, and careful attention to continuous carbon dioxide records and boiler uptake temperatures.—R. E. Thompson.

Improved Apparatus for the Removal of Dissolved Gases from Water. J. R. LORAH, K. T. WILLIAMS and T. G. THOMPSON. J. Am. Chem. Soc., 49: 2991-4, 1927. From Chem. Abst., 22: 516, February 20, 1928. Description of modified apparatus combining good features of VAN SLYKE type (use of vacuum) with those of apparatus described by TREADWELL-HALL (use of heat).—R. E. Thompson.

Ozone, Its Formation and Use. E. H. RIESENFELD. Naturwissenschaften, 15: 777-84, 1927. From Chem. Abst., 22: 520, February 20, 1928. A review.—R. E. Thompson.

Rapid Method for Estimating Active Chlorine. JUSTIN HAUSNER. Melliand Textilber., 8: 874-5, 1927; cf. C. A., 21: 2236. From Chem. Abst., 22: 554, February 20, 1928. Rough titration is carried out against thiosulfate in presence of indigo carmine, a specially graduated stoppered cylinder being used. Lowest mark on cylinder measures definite quantity of hypochlorite, and marks above it are so placed as to read volume of reducing solution in grams per liter.—R. E. Thompson.

The Solubility of Magnesium Oxalate and Its Significance with Respect to the Magnesium-Calcium Separation. M. BOBTELSKY and Frau MALKOWA-JANOWSKI. Z. angew. Chem., 40: 1434-7, 1927. From Chem. Abst., 22: 559, February 20, 1928. Solubility of magnesium oxalate in ammonium oxalate, oxalic acid, and ammonium chloride solutions was determined. With

ammonium oxalate, the solubility both at 15 and 100° increases steadily as the amount of ammonium salt is increased. At latter temperature, 20 grams ammonium oxalate will hold 0.75 gram of magnesium in solution in 100 cc. With oxalic acid, presence of 20 grams only serves to dissolve 0.15 gram of magnesium at 100°, and with same amount of ammonium chloride only 0.033 grams. On basis of these results it is recommended to add 20 grains ammonium oxalate to 100 cc. of solution containing calcium and magnesium. Then, on heating to 100°, calcium oxalate precipitate is obtained free from magnesium even when 0.02 gram calcium chloride is present with 2.70 grams magnesium chloride. Magnesium oxalate will separate out in filtrate after it has stood several hours in cold. With regard to filtering the calcium precipitate, it is found that it is just as well to add oxalate to cold solution and then heat to boiling as to add oxalate to boiling solution. When solution contains considerable magnesium it is possible to obtain granular precipitate which can be filtered as soon as boiling point is reached.—*R. E. Thompson.*

Failure of Slow Sand Filtration in Madras City. J. W. MADELEY. *Surveyor*, 72: 593, 1927. From *Chem. Abst.*, 22: 653, February 20, 1928. Presence of iron sulfide in filter sand gives rise to hydrogen sulfide in hot weather. This collects in pockets and bursts through sedimentary skin, rendering filter useless until refilled. Frequent cleaning and pretreating the sand failed to relieve situation. Proposed to substitute alum treatment and rapid sand filters, employing chlorination where necessary.—*R. E. Thompson.*

Action of Free Chlorine on Microorganisms. F. DIENERT and P. ÉTRILLARD. *Compt. rend.*, 185: 621-3, 1927. From *Chem. Abst.*, 22: 610, February 20, 1928. Only the chemical theory of chlorination and oxidation of the material constituting the microorganisms has so far explained sterilization action of free chlorine.—*R. E. Thompson.*

Natural Mineral Waters in the Light of Modern Research. The Catalytic Action of the Saratoga Springs. OSKAR BAUDISCH and DAVID DAVIDSON. *Arch. Internal Med.*, 40: 496-520, 1927; cf. *C. A.*, 19: 3182, 3198, 3333; SPIRO, *Schweiz. med. Wochschr.*, 45: 1021, 1926; FRESSENIUS, EICKLER and LEDERER, *C. A.* 21: 2039; HEUBNER, *Z. wiss. Baederkunde*, 1: 74, 1926. From *Chem. Abst.*, 22: 650, February 20, 1928. The catalytic activity depends primarily on ferrous iron content, which is most probably in complex form. The waters, when bottled with exclusion of every trace of oxygen, retained full catalytic activity 7 years.—*R. E. Thompson.*

The Moscow Water Supply. E. PRINZ. *Gas- u. Wasserfach*, 70: 1185-6, 1927. From *Chem. Abst.*, 22: 650, February 20, 1928. Present supply is inadequate as quantity which can be drawn from Moskwa River is limited. New sources will be obtained by creating storage reservoirs on some of tributary streams of river.—*R. E. Thompson.*

Acidity of the Waters of Some Puget Sound Bogs. T. G. THOMPSON, J. R. LORAH and G. B. RIGG. *J. Am. Chem. Soc.*, 49: 2981-8, 1927. From *Chem.*

Abst., 22: 651, February 20, 1928. Carbon dioxide may be a contributing, but is not the dominating factor of the acidity. Organic matter content is logarithmic function of acidity, indicating that organic matter is controlling factor of the acidity. Colorimetric and electrometric determinations of acidity gave different results. Practically identical results were obtained in electrometric determination of acidity of the water as such and after evaporation and dilution to original volume.—*R. E. Thompson.*

Oil Pollution of Seas and Harbors—and a Remedy. C. S. GARLAND. *Chemistry & Industry*, 46: 1161-71, 1927. From Chem. Abst., 22: 651, February 20, 1928. The principal sources of this pollution are: (1) discharge of oil-contaminated ballast and bilge, (2) cleaning and flushing of oil tanks at sea, (3) accidents to oil lines in fueling. Oil thus dumped into sea is not destroyed but is eventually washed up on shore. Average oil content of such waste is 2 to 3 per cent, and average ship contains 1000-2000 tons of such material. This requires plant capable of handling 100-200 tons per hour. Effluent must not contain over 1 part oil per 200,000. Oil can be removed to concentration of 0.001-0.004 per cent by gravity separators, and most efficient of these is type employing baffle plates, described in detail. Remainder of oil must be removed by filtration. Of several filtering media tried, glass wool was found adequate, reliable and most efficient because (1) its surface area is 9000 square feet per pound, (2) it will remove 2.83 pounds of oil per pound before clogging, (3) its back pressure is negligible, and (4) it can be cleaned by reversal with steam, which gives a gravity-separable mixture. Plants combining these processes for installation on lighters and aboard ship are described in detail and trials are reported showing capacity up to 250 tons per hour. Comparative methods of analysis of samples containing less than 0.0005 per cent oil reported. Method of precipitating with alumina, extracting with benzene, then drying extract to constant weight at 100 gave best results. Separator has been used for land plants on industrial wastes and found satisfactory.—*R. E. Thompson.*

Detection of Free Chlorine in Potable and Bath Waters. W. OLSZEWSKI and H. RADESTOCK. *Pharm. Zentralh.*, 68: 733-5, 1927. From Chem. Abst., 22: 654, February 20, 1928. Dimethylphenylenediamine, o-tolidin, starch-iodide, and benzidine methods discussed, notably the latter. Preparation of benzidine reagent is described and exact amounts required, together with hydrochloric acid, specified for samples with hardnesses varying from 0.5 to 14 German degrees. Bibliography appended.—*R. E. Thompson.*

The Microdetermination of Iodine in Potable Waters. M. SETTIMI. *Ann. chim. applicata*, 17: 432-46, 1927; cf. C. A., 22: 471. From Chem. Abst., 22: 654, February 20, 1928. In FELLEBERG method for determining minute quantities of iodine (cf. C. A., 17: 2717; 19: 1109, 1466), potassium carbonate may be replaced by sodium carbonate, with several advantages, such as the much lower solubility of sodium carbonate in ethyl alcohol. According to Fellenberg a sufficiency of potassium carbonate is indicated by pasty condition after evaporation, an indication which would not be available if sodium carbonate

was used. Analyses by Settimj indicate that even with excess potassium carbonate losses of iodine may occur, particularly when large quantity of nitrate is present. It is essential that nitrate be destroyed, which may be accomplished by reduction in alkaline medium. Devarda alloy shows absence of iodine even when 0.0001 gram iodine is present. Good results are, however, obtained with zinc dust and excess sodium hydroxide, and addition of excess ammonium carbonate, latter rendering the sodium hydroxide insoluble in alcohol and precipitating zinc carbonate. The organic solvent is of little importance with large quantities of iodine, but tests show that with quantities such as 0.000001 gram of iodine, carbon bisulfide gives most sensitive coloration (compared with chloroform and carbon tetrachloride). This property is, however, not the determinant one, for coefficient of distribution of iodine between solvent and water must be considered. Here, too, carbon bisulfide is by far the best solvent (carbon bisulfide/water 612/1.) Systematic tests with traces of iodine, in which both factors are considered, show that with chloroform nearly twice as much iodine is required to give same coloration as with carbon bisulfide. With less than 0.000001 gram of iodine the method must be further improved to give reliable results. Error in colorimetric method is about 5 per cent for around 0.000001 gram of iodine. Above 0.00015-0.0002 gram the iodine may be titrated with 0.02, 0.01 or 0.002 N thiosulfate. Amounts of order 0.000005-0.00001 gram cannot be detected even with 0.002 N thiosulfate. Considering error involved in such titrations, precision used by FELLEBERG (*loc. cit.*) and by STOKLASA (C. A. 21: 922) in expressed results is not justified. —R. E. Thompson.

Filter Plant Troubles. C. ARTHUR BROWN. Southwest Water Works Journal, 10: 5, 9-13, August 1928. Filter plant troubles naturally divide into two classes: one inherent to design, the other to operation. Provision for measurement of water treated is very important but often lacking. Grit chambers are needed for waters of high turbidity. Over and under type of mixing chamber is considered best. Passageway from mixing chamber should be adequate in size, short, straight, and so operated as not to alter floc. Flow into settling basins over weir extending across entire entry end of basin found most desirable. Value of "split flow" is questioned. Design of settling basins depends on provision for adequate sludge capacity and area and depth of flow zone. Proper baffling is usually helpful. Weir outlet preferable. Inlet and outlet weirs should be adjustable. Flow from basin to filter should be as "quiet" as possible to avoid breaking up floc. Present day filters are far from perfect. Most difficulties are due to faulty washing. Present filter bottom construction practice is criticized. Automatically controlled proportional chemical feed must ultimately become the standard practice. Dry feed of chemicals is considered superior to wet feed. Filter rate controllers should change rates very slowly. Loss of head recording devices now generally employed are of little value, since they do not show sudden variations of pressure across the controller. A superior type is described. Training and experience of operators are very important. Metering of each filter output and daily bacterial analysis of each filter effluent recommended. Errors in chemical treatment and lack of proper washing of filters are responsible for many operating difficulties.—John H. O'Neill.

Engineering Methods Economically Combat Stream Pollution. W. L. SULLIVAN. Chem. and Met. Eng., 35: 483-5, August, 1928. The best means of disposing of acid wastes from a plant bright-dipping small brass parts was found to be by passing the acid solution through tanks containing dolomitic limestone and "glass-house limestone." The solution is diluted to 0.3 per cent acid and then passed through four wooden tanks, the first three being filled with dolomitic limestone and the fourth with a special limestone called "glass-house stone." The effluent is made clear and colorless, and is no longer acid to methyl orange.—*John R. Baylis.*

New Theory For The Centrifugal Pump. A. F. SHERZER. Discussion. Proc. Am. Soc. Civ. Eng., 54: 6, 1801-5, August, 1928. A. B. COX. A notable feature of the head-capacity curves of a steam-condenser circulating water pump with low head and high capacity is the V, or notch, near the middle of each curve. The writer has not been successful in devising a theory for the V-notches. At full capacity the water flows almost radially outward through the impeller of a centrifugal pump and centrifugal force formulas cannot well be applied to the calculation of the head.—*John R. Baylis.*

Baffle-Pier Experiments on Models of Pit River Dams. I. C. STEELE and R. A. MONROE. Discussion. Proc. Am. Soc. Civ. Eng., 54: 6, 1807-19, August, 1928. P. BAUMAN. There should be no appreciable difference between the model and actual conditions in so far as the stilling action is concerned, unless pulsations should develop. A number of equations are given. Baffle-piers or any other kind of obstructions are superfluous in all cases where the river bed is protected by an apron under the full length of the superficial eddy. The writer believes that the notched sill is the best solution of the scouring problem. The height of the sill required is only about $\frac{1}{16}$ to $\frac{1}{4}$ of the difference in the level of the water above and below the dam. M. P. O'BRIEN. Model experiments find their widest use in European laboratories. The principles of dimensional analysis and dynamic similarity cannot be applied blindly.—*John R. Baylis.*

The O'Shaughnessy Dam and Reservoir. J. H. GREGORY, C. B. CORNELI and C. B. HOOVER. Discussion. Proc. Am. Soc. Civ. Eng., 54: 5, 1635-8, May, 1928. W. H. DITTOE and G. G. DIXON. The writers suggest that the O'Shaughnessy dam offers an excellent opportunity for studying the hydraulic jump and related phenomena bearing on the subject of erosion below the dam. They also discuss the desirability of acquiring more land adjacent to water works reservoirs to prevent its use for recreational purposes.—*John R. Baylis.*

Silting of the Lake at Austin, Texas. T. U. TAYLOR. Discussion. Proc. Am. Soc. Civ. Eng., 54: 5, 1649-52, May, 1928. C. SCHULTZ. A reservoir 18 feet deep and $\frac{1}{4}$ mile long, formed by damming a small ravine having a drainage area of about 1,000 acres, was completely filled with silt within ten years. J. B. HAWLEY. The rate of silting varies widely depending on whether the reservoir is a "channel lake" or a "lake," in the usual concept of such a body. The silting of Lake Worth is about 0.5 acre-feet per annum per square mile of

drainage area, and of Medina lake, about 0.3 acre-feet. The velocity of the water in the Austin lake probably carried a great deal of the silt over the dam.
—*John R. Baylis.*

Precise Weir Measurements. E. W. SCHODER and K. B. TURNER. Discussion. Proc. Am. Soc. Civ. Eng., 54: 6, 1767-1800, August, 1928. Ing. TH. REHBOCK. The best weirs for use in field work are nearly triangular in cross-section with sloping down-stream face and with rounded crest. In the laboratory the sharp-crested weir is to be preferred because of its greater precision. Comparison of REHBOCK's formula for calculating the discharge over sharp-crested suppressed weirs without end contraction with others is shown both by formulas and by curves. The formula agrees very well with precise measurements. There is considerable discussion of the weir gaugings made by SCHODER and TURNER. ERIK G. W. LINDQUIST. The formula derived by SCHODER and TURNER does not seem to have a correct theoretical basis. A number of formulas are given in the discussion of certain factors influencing weir measurements.—*John R. Baylis.*

Baffle-Pier Experiments on Models of Pit River Dams. I. C. STEELE and R. A. MONROE. Discussion. Proc. Am. Soc. Civ. Eng., 54: 5, 1549-60, May, 1928. R. L. PARSHALL. The writer describes spillway for a small reservoir to prevent scour below the dam. H. W. DENNIS. The outlet of a tunnel in uncompact material, 12 feet in diameter, for conveying water from one reservoir to another showed no additional scour after first few hours. I. A. WINTER. Models, when properly constructed, give results similar to those of their prototypes.—*John R. Baylis.*

Analysis of Arch Dams by the Trial Load Method. C. H. HOWELL and A. C. JAQUITH. Discussion. Proc. Am. Soc. Civ. Eng., 54: 5, 1585-1603, May, 1928. C. A. P. TURNER. Because of a misconception regarding its mode of resistance, the increase in strength and economy of the curved vertical dam over that of the straight type is little appreciated. A curved dam tends to oppose water pressure predominantly by twisting rather than by arch action. HOWELL and JAQUITH have assumed that the load is carried by the horizontal and vertical elements instead of diagonally in the most direct line of support. A contour of curvature is identical with the principal stress line at the mid-thickness of the plate, consequently their assumption is in error. The writer gives an extended discussion of the stresses in curved dams. F. H. CONSTANT. Equations for determining the bending moment and horizontal thrust are given. The writer believes that the proportionate load distribution found by HOWELL and JAQUITH is correct. F. W. HANNA. Equations for determining the shear are given. There is considerable error involved in the assumption that the cantilevers deflect in radial planes perpendicular to the extrados of the dam.—*John R. Baylis.*

Treatment of Missouri River Water for Locomotive Use. H. H. RICHARDSON. Ind. Eng. Chem., 20: 924-5, 1928. Description of various plants installed by Missouri Pacific R. R. to soften and clarify Missouri River water is

given. This softening has extended life of flues and fire boxes on engines over 200 per cent, with repair work reduced by 55 per cent.—*Edward S. Hopkins.*

Zeolite Filter Plant of Ohio Valley Water Co., Bellevue, Pa. A. H. KNEEN. *Ind. Eng. Chem.*, 20: 951-3, 1928. Softening a clear hard well water undertaken with a plant capacity of six million gallons per day. Description of the installation is given. Manganese is removed by the zeolite and the grains function as filter, eliminating *Crenothrix*.—*Edward S. Hopkins.*

A Modern 4,000,000 Gallon Purification Plant. J. H. KENSTER. *American City*, 39: 3, 87-89, September, 1928. A detailed description of a new 4-m.g. rapid sand filtration plant of conventional design. Provision has been made, however, to chlorinate both the raw and filtered waters.—*Chas. R. Cox.*

An Outline of Water Softening. JOHN F. PIERCE. *American City*, 39: 3, 90-91, September, 1928. A non-technical description of the principles and value of water softening.—*Chas. R. Cox.*

Pollution of Domestic Water Supplies by Unusual Cross Connections. WM. C. GROENIGER. *American City*, 39: 3, 96, September, 1928. A short discussion of the possibility of cross-connection between water supply systems and sewers and drains through improperly designed plumbing fixtures.—*Chas. R. Cox.*

The Chlorination of Auxiliary Water Supplies in New York State. *American City*, 39: 3, 141, September, 1928. A brief discussion of conditions which must obtain to legalize a cross connection between a municipal supply and a non-potable, auxiliary supply after chlorination of latter by use of recently developed equipment which automatically starts when the auxiliary supply is used. The chlorination equipment functions continuously at a slow rate, the solution being wasted except when the auxiliary supply is being used and chlorinated at rate of at least 20 pounds per m.g. of water. Double check valves of the all-bronze type must be used with such cross-connections.—*Chas. R. Cox.*

A Method of Water Prospecting. HOWARD E. SIMPSON. *North Dakota Geological Survey, Bulletin No. 6, Artesian Water Paper No. 4, Grand Forks, North Dakota, 1926.* The author cites the preliminary studies, surveys, and development of a ground water supply for Harvey, North Dakota, from the underflow of the Sheyenne River Valley as a typical solution of the problem of obtaining ground water in that state. The services of a geologist, a chemist, a bacteriologist, and an engineer are required; the geologist to locate the water in sufficient quantity, the analysts to determine the chemical and bacterial qualities, and the engineer to pass upon the feasibility and method of its economic utilization.—*R. L. McNamee.*

The Conservation of Artesian Water. HOWARD E. SIMPSON. *North Dakota Geological Survey, Bulletin No. 5, Artesian Water Paper No. 3, Grand Forks, North Dakota, 1926.* The artesian system formed by the Dakota sandstone yields flowing wells throughout large areas in eastern North and South D -

kota and in smaller areas in Minnesota, Iowa, and Nebraska. Early wells yielded 500 to 4,000 gallons per minute at pressures ranging from 100 to 250 pounds per square inch, whereas at present many of these do not flow at all. The waste of artesian water has now been reduced by coöperation between the State Water Geologist, drillers, and owners under an Artesian Water Law. The full text of the law and of the Second Biennial Report of the State Water Geologist are given.—*R. L. McNamee.*

The Activated Sludge Plant at Grand Canyon, National Park, Arizona. JANE RIDER, Southwest Water Works Jour., 10: 12-14, August, 1928. Water has to be hauled 100 miles from Flagstaff or 122 miles from Puro. Present water consumption is from 50,000 to 110,000 gallons per day of clear water and approximately 72,700 gallons of reclaimed sewage. On account of the high cost of water the sewage is treated so that the effluent can be used for industrial purposes. The treatment plant comprises double compartment coarse bar screen chamber, presettling tank with double hopper bottom; two aëration tanks, using ridge and furrow system with Filtros plates for air inlets; Dorr clarifier for aërated sewage, sedimentation chamber for Dorr tank effluent, two rapid sand filter units, clear well for filter effluent, and chlorinator. Details are given as to capacity and size of units. Used filter wash water is returned to the presettling tank. Orthotolidine test is used to control chlorine dosage. Suspended matter is reduced to about 3 p.p.m. in clear well from 138 to 389 p.p.m. in the raw sewage; ammonia nitrogen is reduced 97 to 99 per cent; dissolved oxygen averages from 3.1 to 6.0 p.p.m.; while the B.O.D. varies from 0.5 to 2.5 p.p.m.—*John H. O'Neill.*

Time Savers in Water Analysis. F. E. DANIELS. Public Works, 59: 213-215 and 282-284, 1928. The routine practices of the laboratory of the Pennsylvania State Board of Health in water analysis are described in detail. Individual counter weights for silica dishes, a method of fast weighing, and a cabinet desiccator expedite the work. The apparatus and methods for the determination of free and albuminoid ammonia, chlorides, nitrates, nitrites, total hardness, alkalinity, color, odor, hydrogen ion, solids, iron, and oxygen consumed are included.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Deep Well to Provide Water Supply for New Community. Anon. Water Works, 67: 155-157, 1928. The proposed water supply for Villa Park, Illinois, with a population of 6,000 is a 10-inch well which will tap the lower Potsdam sandstone at a depth of 2,200 feet. A deep well pump with a capacity of 700 to 1,000 g.p.m. will deliver the water into a 200,000-gallon covered reservoir. A 1,000-g.p.m. booster pump which will build up a pressure of 50 pounds will pump the water into the existing 12- and 6-inch mains.—*C. C. Ruchhoft.*

Water Works in 1927. Anon. Public Works, 59: 231-239, 1928. Statistics collected by *Public Works* on the various kinds of pipe laid; on hydrants, valves, and meters placed, and service connections made; on services and meters in active use; and on pumps and pumping for 1927 are tabulated.—*C. C. Ruchhoft.*

The Mokelumne Water Project. Anon. *Public Works*, 59: 209-211, 1928. The Mokelumne water supply project of the East Bay Municipal Utility District of California comprising Oakland, Berkeley, and seven other communities is described. The project will include 2 primary storage reservoirs having a capacity of 76,269 million gallons, four distribution reservoirs, 81 miles of pipe, and three concrete lined pressure tunnels from 11,659 to 18,694 feet long. The line is constructed from 65-inch diameter pipe having the longitudinal seams electrically welded and the field joints riveted.—C. C. Ruchhoft.

Lining Westerly's Concrete Standpipe. Anon. *Public Works*, 59: 212, 1928. To repair a 650,000-gallon concrete standpipe which was leaking, the inside of the pipe was cleaned, lined with a waterproof membrane including 4 layers of felt and 5 layers of hydrex compound and a core of brick constructed from the floor to the top. The brick lining was washed down with cement and Celite.—C. C. Ruchhoft.

Recreational Use of Watersheds of Public Water Supplies. W. L. STEVENSON and H. E. MOSES. *Waterworks*, 67: 254-5, 1928. There has been a pressing demand to use watersheds of water supplies for recreational uses such as camping, fishing, bathing, etc., and one state has passed a law allowing this use of watersheds provided no trespass is committed. The riparian rights of owners of land abutting on water sources complicates this problem. Remedies which are suggested for safeguarding public supply watersheds against contamination through recreational use include zoning, placarding, sanitary control, education of public, and legislation.—C. C. Ruchhoft (*Courtesy Chem. Abst.*).

English View on Rapid Sand Filtration. (Abstract of paper by S. W. FARRINGTON before the Irish District of the Institution of Municipal and County Engineers) *Public Works*, 59: 278-280, 1928. FARRINGTON comparing American and British water works practice found that in general American practice is much more standardized than British; but automatic control of chemical dosing for proportioning in accordance with water flow is more common in England than in America. The use of settling tanks is less common in British practice. On the average Americans use higher filtration rates. Filter washing with water and air, or stirring, while not usually used here is considered essential in England.—C. C. Ruchhoft.

New Water Works and Filtration Plant at Laredo, Texas. R. T. REILLY. *Water Works*, 67: 247-8, 1928. The new filter plant located on high ground upstream from the source of pollution has its intake in the Rio Grande River and includes low lift pumps, aerators, mixing and coagulation basins, filters, clear well, and high lift pumping station. The mixing will be accomplished in circular tanks by peripheral velocity without mechanical agitation. The settling basins are circular with a total detention period of 6 hours. There are 4 filters with a total capacity of 6 m.g.d.—C. C. Ruchhoft.

Asphalt Grouting for Waterproofing and Stopping Leakage. GEORGE W. CHRISTMAS. *Water Works*, 67: 225-6, 1928. One side of the Columbia Dam in Tennessee was carried into the bank some 15 to 20 feet to apparently watertight formation; but later, leakage of about 3 cubic feet per second developed. A number of holes were drilled about 6 feet upstream from the dam opposite the leakage outlet and into these holes were pumped about 37 drums of asphalt. This treatment stopped the leakage entirely.—*C. C. Ruchhoft.*

Free Water at Cleveland, Ohio. HOWELL WRIGHT. *Water Works*, 67: 172, 1928. The municipal and filtration plant furnishes 26.48 per cent of the filtered water pumpage without revenue. This non-revenue-producing water goes to the tax supported city departments for fire protection, street cleaning, sewer flushing, and for parks and playgrounds. Free water is also furnished public schools, parochial schools, city markets, public buildings, city cemeteries, public libraries. It is believed that this free water policy encourages waste and is unwarranted and unnecessary.—*C. C. Ruchhoft.*

The New Bloomington, Indiana, Water Works. PAUL HANSEN. *Water Works*, 67: 219-221, 1928. The original Spring Branch impounding development with the addition of a new dam below the original one with a rectangular concrete basin below the second dam to catch leakage proved inadequate in 1908. An additional supply obtained from a new reservoir of 50 m.g. capacity known as Weimers pond helped the situation until 1913 when a severe shortage occurred. At this time engineers were retained by the city and recommended the development of Griffy's Creek as an impounding reservoir, but the continuous flow from some limestone springs appealed to the official mind and in spite of the engineers recommendations this was developed. In 1920 and 1922 shortage again occurred and other competent engineers were employed; and in both cases the development of the Griffy's Creek supply was recommended. The project was finally undertaken in 1924 and an adequate supply of 2.5 m.g.d. was assured in dry years. A 2-m.g.d. filter plant including pumping station was built to purify the new supply. This experience illustrates that in general needed improvements in municipal water supplies require from five to ten years for their realization.—*C. C. Ruchhoft.*

Elements of Successful Coagulation and Filtration. HARRY N. JENKS. *Water Works*, 67: 203-6, 1928. *Can. Engr.*, 54: 630, 1928. Adequate pretreatment of the water applied to rapid sand filters is an important factor in maintaining high standard effluents. Proper design of chemical feed apparatus and of mixing devices is necessary for insuring accurate measurement of chemicals and proper flocculation. Mechanical stirring devices are considered better than gravity mixers. The well formed floc should not be broken up and the well clarified water should carry a residual well formed floc as it reaches the filters. The influences of plant design and operating methods on filtration are discussed.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Grand Haven, Michigan, Gets New Water Works. Anon. *Public Works*, 67: 191-6, 1928. The new filtration plant obtains its water from Lake Michi-

gan, has a capacity of 2 m.g.d., and is so arranged that it can be enlarged to four times its present capacity. Pumping equipment includes three units with a total capacity of 3.5 m.g.d. Storage is provided for 1.6 million gallons of water in a clear water basin under the filters and an elevated reservoir. The filter plant has dry-feed chemical equipment, a spray nozzle aerator, a reaction chamber equipped with stirring devices and baffles, two sedimentation basins having a retention period of four hours, and four filters.—C. C. Ruchhoft.

The Cause of the St. Francis Dam Failure. H. P. GILLETE. *Water Works*, 67: 181-6, 1928. The four theories which have been presented as to the cause of the failure of the St. Francis Dam are discussed. These theories are: (1) A natural land slide on the eastern, or lefthand, side of the dam. (2) A softening of the conglomerate under the west side of the dam due to seepage, and a slipping of the west end of the dam on, or with, the softened foundation; (3) An explosion at one or both ends of the dam; (4) An earthquake or other major movement. The author believes the first theory to be correct and presents data and photographs which favor that view.—C. C. Ruchhoft.

Relation of Rate of Discharge to Pressure Head. F. W. GREVE. *Water Works*, 67: 180, 1928. Circular orifices from 2.5 to 8 inches in diameter in pipe caps on the ends of pipe from 4 to 10 inches in diameter were calibrated with relatively high velocities of approach.—C. C. Ruchhoft.

Three Unreliable Reports on the St. Francis Dam Failure. Anon. *Water Works*, 67: 177-8, 1928. The reports on the failure of the St. Francis Dam by three committees of experts, the governor's committee, the district attorney's committee, and the Los Angeles city council committee, are criticized as being unreliable. All of these reports were hastily made and all of them failed to discuss any theory of the dam failure except that of a soft conglomerate foundation on the west side to which the first break was attributed.—C. C. Ruchhoft.

Water Sampling Devices for the Water Works Operator. J. D. EDAL BEHAM. *Munic. News and Water Works*, 75: 3-4, 1928. Three water sampling devices, one for automatic sampling at regular intervals, are described and illustrated.—C. C. Ruchhoft.

Gaining Additional Capacity in Standpipe. S. S. GEAR. *Munic. News and Water Works* 75: 4, 1928. The standpipe at Niagara Falls, Ontario, was a steel cylinder 14 feet 4 inches in diameter and 100 feet high. It was enlarged by removing the upper 34 feet and building in place a section 28 feet 8 inches in diameter with an elliptical bottom and a conical top. The elliptical bottom was framed into the original standpipe.—C. C. Ruchhoft.

Meter Rates in Municipalities of over 200,000 Population. Anon. *Munic. News and Water Works* 75: 31-2, 1928. Data on meter rates collected from 33 cities are presented.—C. C. Ruchhoft.

Analysis of Arch Dams by the Trial Load Method. C. H. HOWELL and JAQUITH. Discussion. Proc. Am. Soc. Civ. Eng., 54: 6, 1879-98, August, 1928. L. J. MENSCH. A number of equations are given for computing stresses in arched dams. If the weight of the arch ring is considered, the most economical design is obtained by assuming the plane of the arch to be on an incline. Starting the design of an arched dam should be done by properly designing the inclined arches. WILLIAM CAIN. A very good discussion is given of the stresses that may occur in an arched dam.—*John R. Baylis.*

Silting of the Lake at Austin, Texas. T. U. TAYLOR. Discussion. Proc. Am. Soc. Civ. Eng., 54: 6, 1938-51, August, 1928. H. F. ROBINSON. The Zuni Reservoir in New Mexico is circular in shape and silted to approximately 95 per cent of its storage capacity within twenty-two years. There is no practical method of removing silt once it has deposited in a large reservoir. The best procedure is to prevent, as far as is practical, silt being carried into the reservoir. JULIAN MONTGOMERY. Streams in the Southwest carry considerable silt and it is not unusual for engineers to allow 0.3 to 0.5 acre-feet of siltage per year per square mile of drainage area. KIRK BRYAN. Years of large precipitation, due to the increased growth of vegetation, may actually decrease the silt carried by the run-off, whereas less rain, or overgrazing by cattle, may increase the silt even though there is less run-off.—*John R. Baylis.*

Upward Pressure Under Dams: Experiments by the United States Bureau of Reclamation. JULIAN HINDS. Discussion. Proc. Am. Soc. Civ. Eng., 54: 6, 1953-59, August, 1928. C. TERZAGHI. When the permeability of the underground is the same in a vertical and a horizontal plane the BLIGH empirical rule that a row of sheet-piling should increase the effective distance of percolation by an amount equal to twice the depth of the sheet-piling holds very well, though such conditions usually do not exist. The hydrostatic uplift of masonry dams founded on solid rock is uncertain. Solid rock with fairly wide groutable fissures may be more favorable than rock with narrow fissures that cannot be grouted. The narrowest seam that can be grouted has a width of about $\frac{1}{8}$ inch, while the narrowest seam through which pressure can be transmitted is about $\frac{1}{500,000}$ inch. J. C. STEVENS. It is believed that the proper manner to treat pressure uplift under dams in the design is to assume that the pressure area covers the entire base. F. W. HANNA. Filter action in the stream beds above the dams is of small importance in the design of dams made to withstand the worst uplift condition. Conditions to give results in conformity with BLIGH's theory rarely occur in the foundation of dams.—*John R. Baylis.*

Load Distribution in High Arch Dams. R. A. SUTHERLAND. Discussion. Proc. Am. Soc. Civ. Eng., 54: 7, 2151-56, September, 1928. WILLIAM CAIN. Nearly all dams are fixed at the base in the sense of supplying sufficient tensile resistance there and cracks will occur. The equation for computing deflection is discussed. B. F. JAKOBSEN. If it is assumed that the arch load at the abutment is zero, this is not correct. The cantilever deflections and the arch deflections are materially increased by the yielding of the foundation. The

possibility of improving arch dams lies in the direction of grouting the construction joints so as to make a monolithic structure which will have compressive arch stresses in places when the reservoir is empty. Mr. SUTHERLAND is correct in that the cantilevers have vertical radial limiting planes and vertical parallel planes.—*John R. Baylis.*

Dangers of Waste Waters from Abattoirs and their Purification. G. BREVOT. *Mouvement Sanitaire*, 1927, 3: 434-43. *Bull. Hyg.*, 3: 434, May, 1928. Special risks associated with abattoir sewage are presence of bacteria pathogenic to man and animals and of the eggs of parasitic worms and high content of fat and of decomposable organic matter. Bacterial content was 347 millions of aërobes per cubic centimeter. For disposal it is suggested first that blood and contents of paunches and intestines be excluded from sewers; that sedimentation be accomplished by some device like a hydrolytic tank; and that then the effluent be subjected to biological purification, using land filtration or septic tank and separating filter in combination. Non-decomposable effluent may then be sterilized.—*Arthur P. Miller.*

A Study on the Waste Water of Paper Mills. N. WATANABE. *J. Pub. Health Ass. of Japan*, 1927, 3: 7, 1-16. *Bull. Hyg.*, 3: 434-435, May 1928. The types of waste studied were the results of the following processes: (1) boiling straw with lime by use of heated steam and after removal of the paper; (2) heating manila hemp or other refuses with lime followed by (3) a combination of (1) and (2). Wastes vary in quantity from hour to hour and when decomposing turn black, giving off foul odors. As to the germicidal effects, (2) in original form killed cholera vibrio in eight hours, *Bact. typhosum* in four to eight hours, and *Bact. dysenteriae* in two to four hours. (1) and (3) had no such power. Trying the wastes on fish seemed to indicate that they do not kill at once and that after a time the fish become immune; however, they become unfit to eat. After the wastes decompose, they kill fish. Sulphuric acid as a decolorizing agent was more effective than sodium bisulphite. The effects on sanitation of the district seem to be an increase in mosquitoes and interference with swimming and fishing.—*Arthur P. Miller.*

The Diurnal Variation of the Gaseous Constituents of River Waters. R. W. BUTCHER, F. T. K. PENTLOW and J. W. A. WOODLEY. *Biochem. J.*, 1927, 21: 945-57. *Bull. Hyg.*, 3: 431-432, May, 1928. This article is opened with a historical introduction on the subject. To continue the study, observations were made on the River Lark in connection with pollution from a sugar beet factory. The summary of the results can best be quoted:—"Day. Photosynthesis by plants causes assimilation of carbon-dioxide and liberation of oxygen, while decay of organic matter produces ammonia which is removed by the high concentration of oxygen, resulting in oxygen maximum, ammoniacal nitrogen minimum, pH value maximum. Night. Photosynthetic production of oxygen ceases and ammonia produced by organic matter is not removed. Animal and plant respiration continues taking up oxygen and producing carbon dioxide resulting in oxygen minimum, ammoniacal nitrogen maximum, pH value minimum."—*Arthur P. Miller.*

The Diurnal Variation of the Gaseous Constituents of River Waters. Part II. R. W. BUTCHER, F. T. K. PENTELow, and J. W. A. WOODLEY. *Biochem. J.*, 1927, 21: 1423-35. *Bull. Hyg.*, 3: 433-434, May, 1928. Further studies of the gaseous content of the River Lark are recorded. The data show that when the river temperature is highest, the ammoniacal nitrogen is lowest and the oxygen in solution is at its lowest; conversely, when the temperature is lowest, opposite conditions prevailed. This state was confirmed on more than one day. In the oxygen curve, there is a noticeable shortening of the period of minimum oxygen from March (six hours) to May (two hours) while July and August give a single minimum value. These differences are attributed to variation in duration of darkness. Meteorological conditions appear to have more effect on the time of increase of the oxygen from minimum value than the time of sunrise. Weather conditions have considerable effect on the times of maximum and minimum values also. On the River Itchin, no diurnal variation of ammoniacal nitrogen is recorded; but on the Lark, these curves were generally the same as for previous studies.—*Arthur P. Miller.*

Methods of Estimating Pollution in Tidal Estuaries and Water Reservoirs. D. ELLIS. *Official Circular Brit. Waterworks Assoc.* 69: 10. *Bull. Hyg.*, 3: 430-431, May, 1928. The author discusses biological tests as opposed to chemical tests for measuring the amount of organic matter in polluted water, pointing out several weaknesses in the chemical tests. Biological tests are described as being direct estimates of the very matter on which information is required. The activities of iron and of sulphur bacteria are such as to make them useful in detecting and estimating pollution.—*Arthur P. Miller.*

Estimation of Organic Matter in Sewage and Effluent. W. E. ABBOTT. *Ind. Eng. Chem.*, 19: 919-21. *Bull. Hyg.*, 3: 422, May, 1928. A method for determining organic matter in sewage by using potassium dichromate is given. The dichromate test affords a better index of purification progress in sewage treatment than the permanganate absorption test.—*Arthur P. Miller.*

Some Methods of Analysis of Sewage and Water. F. R. O'SHAUGHNESSY, C. H. HEWITT and A. S. MILLER. *Surveyor*, 1927, 72: 494-5. *Bull. Hyg.*, 3: 421-422, May, 1928. A short review is given of views and criticisms recently put forward regarding methods of sewage analysis, with particular reference to tests for albuminoid ammonia, oxygen absorption, and the determination of colloids.—*Arthur P. Miller.*

Rivers Pollution Prevention. J. H. GARNER. *Surveyor*, 1927, 72: 71-3. *Bull. Hyg.*, 3: 429, May, 1928. The author concludes "that at the present time the aggregate amount of pollution of streams is about stationary; but that there is a marked tendency for that pollution to become more widely spread and varied in character, thereby leading to an averaging of the quality of those streams affected."—*Arthur P. Miller.*

A Report on an Investigation into the Desiccation of Sugar Beet and the Extraction of Sugar. B. J. OWEN. Ministry of Agriculture and Fisheries.

Appendix V. 79-84. **Treatment of Effluents.** Bull. Hyg., 3: 435-436, May, 1928. As the beet sugar industry increases, the problem of disposing of their wastes becomes more important. Aside from the pulp-press and diffusion waters, consideration must be given to the waters used for fluming and washing the beets which represent major part of the total wastes released by a factory. After the removal of suspended matter before decomposition starts, the author suggests two methods to render the organic matter innocuous: "(1) Treatment, either biological or chemical, so as to bring the whole of the effluent to a condition which ensures of its discharge into any river without objectionable results. (2) A system of recirculation of the clear bright effluent so that only a small proportion, if any, need be discharged into the river."—Arthur P. Miller.

The Solution of Oxygen in Sewage. A. S. PARSONS and H. WILSON. Surveyor, 1927, 72: 490-94. Bull. Hyg., 3: 422-423, May, 1928. This article describes an experiment designed to test the validity of the belief by many that the method of getting oxygen into solution in the activated sludge sewage disposal process by breaking the surface of the liquid is better than by blowing in an air current, because in the former method air passes slowly into solution from the surface of small bubbles. Two 18-inch pipes, one 7 feet and the other 25 feet in depth were fitted with similar diffusers and with arrangements for drawing samples at any desired depth. The pipes were filled with a mixture of sewage and activated sludge, the quantity of air controlled and checked and samples taken at regular time intervals. Within the limits of experimental error it was found that dissolved oxygen content of the sewage was the same at bottom, middle and top of the pipes. The sludge in the deep pipe settled with difficulty but more quickly in the shorter one. Rate of purification was reduced by altering the pH of the sewage.—Arthur P. Miller.

Influence of Forests on Rainfall. Canadian Engineer, 1927, 53: 637-9. Bull. Hyg., 3: 658-659, August, 1928. A brief discussion as to whether the floral covering of the soil influences the rainfall is given. It is concluded with the following observations: (1) Replacement of forests by field crops slightly increases rainfall; the converse is true when bare ground replaces forests. (2) Forests increase local rainfall slightly due to increase of effective ground level due to height of trees. (3) On account of mechanical collection of clouds about forests, favorable conditions are increased. (4) Replacement of forest by crop lands decreases the run-off while replacement by bare soil increases it although making it more irregular.—Arthur P. Miller.

Sources of Underground Water Supplies: the Need for Investigation. S. R. RAFFETY. Surveyor, 1927, 72: 601-2. Bull. Hyg., 3: 659, August, 1928. Although it is essential that fullest use of underground waters be made, it is not surprising that official agencies hesitate to approve new developments for fear of harming those already in use. This opinion is based on the paucity of data on underground water supplies and on the haziness of the theories controlling the conclusions of engineers relative to the available water per unit of area, the contributory area, and the effect of pumping. The article makes

a plea for the collection and collation of all hydrological data, that on water levels, amount of water pumped, rainfall, and local geological characteristics.—*Arthur P. Miller.*

The Art of the Water Diviner. W. H. LETHEREN. *Surveyor*, 1928, 83: 279-80. *Bull. Hyg.*, 3: 659, August, 1928. The author presents data as further proof that the art of water divining is not mythical. He cites personal experiences to show that the movements of twigs have indicated the location of water and that such locations have been confirmed later. [The abstractor believes that individual personal experience will constitute the best proof of the value of this art.]—*Arthur P. Miller.*

The Aërial Well. A. KNAPEN. *Mouvement Sanitaire*, 1927, 3: 736-40. *Bull. Hyg.*, 3: 659, August, 1928. A device for obtaining a continuous supply of water in dry climates or deserts is described. In a specially built tower, there are arranged rows of pipes "sloping from without inwards in the lower half, and in the opposite direction in the upper half though proportionately smaller, thus allowing a circulation of air." Broken stones are piled within and moisture condenses on their sharp angles. Arrangements are provided for catching and storing the water.—*Arthur P. Miller.*

Water Supplies in Towns and Country Districts of Haiti. C. S. BUTLER. *Bull. Soc. Med. d'Haiti*, 1927, July, 1: 13-16. *Bull. Hyg.*, 3: 660, August, 1928. Owing to the primitive habits of the Haitians, all the water sources are heavily contaminated. The gourd is used for carrying water and chlorination of the water in it cannot be done because the organic matter of the gourd consumes the chlorine. A campaign of propaganda for improving conditions is suggested.—*Arthur P. Miller.*

Engineering Bulletin No. 3, Maryland State Department of Health. ABEL WOLMAN, Chief Engineer. 144 pp. April, 1928. Bulletin contains engineering reports and studies of more general interest which have been accumulated in normal operations of the Department since 1925 (date of previous bulletin), and the proceedings of the First Annual Conference of Maryland Water and Sewage Plant Operators. **How Much Water Does a Consumer Require?** ABEL WOLMAN. 58-64. "Subsistence demand" of man is rarely over 1½ gallons per day. British troops under General ALLENBY in forced marches against Turks used as low as 1 pint per man per day. "Sanitary demand" varies between 10 and 20 gallons per person per day. Sum of these gives "rational requirement" of 15-25 gallons with maximum of 30 gallons per day. Per capita consumption per day in London, Eng., is less than 50 gallons, while average for principal towns in Great Britain is only 42 gallons. Fifty gallons is considered to be "maximum reasonable use." Statistics given which indicate that there is no correlation between water consumption and disease. **Chart for Determining Chlorine Dosage.** JAMES R. MCCOMAS. 65-6. Nomograph for liquid chlorine and commercial hypochlorite of lime given. **Efficiency of a Tannery Waste Treatment Works.** T. C. SCHAEZLE and A. W. BLOHM. 73-84. Results are given of study of waste treatment process at

tannery in Maryland. The wastes, which amount to approximately 28,000 gallons per day, are passed through a Dorreo screen and then through a Dorreo thickener, effluent from latter being discharged into a stream. Screenings are recovered and sludge from thickener is pumped into drying beds, from which there is an overflow to large lagoon. Removal of suspended solids is only approximately 44 per cent and oxygen-consuming power is reduced 26.1 per cent. Effluent has biochemical oxygen demand (distilled water) of 1747 p.p.m., and relative stability with stream water ranges from 75 to 98 per cent. Experiments indicated that clarification of effluent could be effected with iron and lime or with alum, iron, and lime. **The Operation and Control of Rapid Sand Filters.** S. T. POWELL. 107-13. Cf. this Journal 19: 119. **Some Practical Hints on the Maintenance of Water Systems.** CARL A. HECHMER. 114-23. Practical maintenance ideas used with success in Washington Suburban Sanitary District are described. The Mathews fire hydrant with several modifications designed by ROBT. B. MORSE has been found particularly adaptable to areas where changes in grade are made after installation. The barrel is made in different lengths and frost casing is made in 2 lengths permitting shortening or lengthening within total range of 2 feet. Hydrants are inspected 3 times each year: in early fall, winter, and spring. Record on card system is maintained and for quick reference a map is used, made on 600 foot scale and mounted on wall board. Push pins show location of each hydrant, color of pin denoting its condition. Colored discs under pins indicate make of hydrant and small celluloid flags are used to show date of last inspection. Blockage of hydrant drain can usually be cleared by leaving nozzle caps on and opening main valve one turn, 3 turns being required to close drain valve on most hydrants. Distribution valves should be operated regularly. Leakage through valves can usually be remedied by operating them up and down, bringing gate down into groove hard each time and then opening about one quarter way. Instance cited of one valve being so operated 30 times and becoming perfectly tight. Posts are used to indicate location of main line control valves in undeveloped sections. Great success has been attained in use of portable hand pump in relieving complaints of low pressure or insufficient supply in house connections. Electric pipe locator has been found most useful. After little practice anyone can secure dependable results with this instrument. Hundreds of dollars have been saved by use of electric leak locator. Aquaphone has also been found most useful in detecting leakage in house plumbing and locating valves which do not shut properly. Dip needle is almost indispensable for locating valve and curb cock boxes which have become covered with earth or paving material. Tool for recovering lost pump rods from wells and another for raising a pipe out of a well are described. It has been found good practice to drill small hole in casing of wells about 4-5 feet below ground surface to permit drainage during freezing weather. Discharge valves on centrifugal pumps are always slowly closed before shutting down pump, in order to minimize water hammer in force mains. Pressure relief valves have been installed in one long force main, set to open at 15 pounds above maximum operating pressure, to prevent damage due to hammer in event of sudden shut down due to accident. Water ejector is employed for priming centrifugal pumps. This eliminates necessity of foot valve, and cost

is very much less. Greatest advantage, however, is protection given pump itself from back pressure or water hammer if pump is shut down suddenly. Connections are illustrated. **Laboratory Control of a Modern Water Purification Plant.** EDWARD S. HOPKINS. 125-6. Brief outline and discussion of tests employed in laboratory control of water purification. Application of coagulant can be accurately controlled by laboratory experiments with mechanical stirrer and sand filter. This procedure makes possible operation of plant within 10 per cent of theoretical efficiency.—*R. E. Thompson.*

Building a 375-Mile Pipe Line in 193 Calendar Days. WM. THOMPSON SMITH. Eng. News-Rec.; 101: 509-14, October 4, 1928. Detailed illustrated description of construction of Amarillo-Denver pipe line, which includes in main line 235 miles of 22-inch, and approximately 105 miles of 20-inch lap-welded, open-hearth steel pipe. In 193 calendar days there was laid in trench much of it in rock, average of 1.96 miles of pipe per day. Degree of corrosion to be expected was studied by field inspection and soil samples taken to depth of 5 feet at all points along right-of-way where definite changes in topographical conditions were found. Maximum distance between soil sampling points was 1 mile. Protection of pipe was varied to suit conditions found. Heavy protective coating was employed on 50.5 per cent, light coating on 42.3 per cent and no protection was provided on 7.2 per cent of line. Heavy protection consisted of cold prime coat followed by hot application of coal-tar base enamel, and light protection, of application of coal-tar base coating brushed on cold. Details given of river crossings.—*R. E. Thompson.*

NEW BOOKS

The Principles of Sanitation. C. H. KIBBEY. Philadelphia: F. A. Davis Co. Cloth; 6 x 9 in.; pp. 354. \$3.50. Reviewed in Eng. News-Rec., 100: 634, April 19, 1928.—*R. E. Thompson.*

Steam Turbines. EDWIN F. CHURCH, Jr. New York and London: McGraw-Hill Book Co. Cloth; 6 x 9 in.; pp. 273. \$3. Reviewed in Eng. News-Rec., 100: 636, April 19, 1928.—*R. E. Thompson.*

Das Fassungsvermögen von Rohrbrunnen und seine Bedeutung für die Grundwasserabsenkung, insbesondere für grobere Absenkungstiefen. WILLY SICHARDT. Berlin: Julius Springer. Paper; 6 x 9 in.; pp. 89. 7.5 reichmarks in Germany. Reviewed in Eng. News-Rec., 100: 786, May 17, 1928.—*R. E. Thompson.*

Wasserabfluss Durch Stollen. ERNST SCHLEIERMACHER. Paper; pp. 60. Munich; R. Oldenbourg. 5.5 reichmarks. Reviewed in Eng. News-Rec., 100: 979, June 21, 1928.—*R. E. Thompson.*

Surface water supply of U. S.; Hudson Bay and upper Mississippi basins. Geol. Survey water supply paper 585.—*Arthur P. Miller.*

Surface water supply of U. S.; lower Mississippi River Basin. Geol. Survey water supply paper 587.—*Arthur P. Miller.*

Surface water supply of U. S.; North Pacific Slope, drainage basin and Snake River Basin. Geol. Survey water supply paper 573.—*Arthur P. Miller.*

Surface water supply of U. S.; Pacific slope basins in California. N. C. GROVER, H. D. MCGLASHAN and F. F. HENSHAW. Geol. Survey Water Supply Paper 571. Includes stream-gaging stations and data relating to water resources.—*Arthur P. Miller.*

Contributions to hydrology of U. S. N. C. GROVER. Geol. Survey Water-supply paper 576. Includes following papers:—**Methods of exploring and repairing leaky artesian wells**, JOHN MCCOMBS, ALBERT G. FIEDLER, and OSCAR E. MEINZER. **Quality of water of Colorado River in 1925-26**, W. D. COLLINS and C. S. HOWARD. **Ground water in Ordovician rocks near Woodstock, Va.**, GEORGE M. HALL. **Quality of water of Pecos River in Texas**, W. D. COLLINS and H. B. RIFFENBURG. **Quality of surface waters of New Jersey (with bibliography)**, W. D. COLLINS and C. S. HOWARD. **Laboratory tests on physical properties of water-bearing materials**, NORAH DOWELL STEARNS. **Chemical character of waters of Florida**, W. D. COLLINS and C. S. HOWARD. **Notes on practical water analysis**, W. D. COLLINS.—*Arthur P. Miller.*

Surface water supply of U. S.; South Atlantic slope and eastern Gulf of Mexico basins. M. C. GROVER, A. H. HORTON, W. E. HALL and W. R. KING. Geol. Survey water supply paper 582.—*Arthur P. Miller.*

Stream Pollution in the United States. Monograph relating to the Pollution and Obstruction of Navigable Streams in the United States by Sewage and Industrial Wastes. U. S. House of Representatives. 69th Congress, 2nd Session, Document 632: 31. From Bull. Hyg., 3: 430, May, 1928. This monograph deals with stream pollution and the disposal of sewage and industrial wastes. The conclusion is drawn that as much waste as can be economically recovered should be, thereby benefiting both the streams and the community.—*Arthur P. Miller.*

Gespannte Wässer: HERMANN KELLER. 1928 Halle; W. Knapp. 90 pp. From Bull. Hyg., 3: 545, June, 1928. This volume considers underground waters from the viewpoints of where such are apt to be found; laws of flow and resistance; well yield and factors affecting; and legal aspects as conceived in Germany. Bibliography contains 97 references.—*Arthur P. Miller.*